POWER

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The Right to Resign

IT IS insisted with vehemence that since the emancipation proclamation no man is subject to involuntary servitude — But:

Have the doctors of a community any right to shut up their offices and go on a vacation at the time of an epidemic?

Have the members of a fire department any right to choose the time of a great conflagration to enforce their demand for an increase of wages with the alternative of letting the city burn?

Have the men to whom the preservation of the public peace has been intrusted any right to doff their uniforms and turn the community over to the mercies of the lawless to cinch a personal advantage to themselves?

Have the men upon whose operation of the railways and other means of transportation the people are dependent, not only for their own comings and goings, but for their food and fuel and other supplies, the right to jeopardize the health and comfort and earning power of the community to enforce their terms upon their employers?

If labor is not a commodity, subject to legislation against conspiracy in restraint of trade, which it is allowed that it is not, it has responsibilities with regard to the public which cannot be ignored.

When industry was simple and a disagreement between a single employer and a small group resulted in the refusal of the group to continue at work under existing conditions, the issue was of smaller public moment, although it did involve seriously the orderly processes of local trade and affected the prosperity of those not concerned in the dispute.

A disturbance of the present highly organized and intricately interdependent social and industrial system is a matter of such baleful effect to so many innocent and disinterested people as to be, when deliberately and purposely brought about, a matter of the deepest public concern which the body politic cannot continue to tolerate.

The recent utterance of the President that in case the owners and purveyors of the anthracite supply of the country and the men who labor to make it available cannot come to terms, and those dependent upon it are left without fuel, he and his Administration have no power to enforce the resumption of operations and the re-establishment of a stable supply, is fraught with significant suggestion of the power that a collective and long-suffering people have refrained from asserting for their own preservation.

F. R. Low

Big Four Railroad Reduces Power Costs

Beech Grove Shops Install Mixed-Pressure Turbine, Saving 50 per Cent of Cost Each Year—Turbine Uses Exhaust from Non-Condensing Turbines and Steam-Driven Air Compressors

WHILE railroads have given considerable thought to conserving fuel used in transportation, there are still great opportunities of fuel saving in the power plants serving the repair shops. Consequently, the marked reduction made by the C., C., C. & St. L. Ry. in the power costs at the Beech Groove shops excites interest. This is especially true because the improvementwas obtained largely through the relatively inexpensive addition of a mixed-pressure turbine.

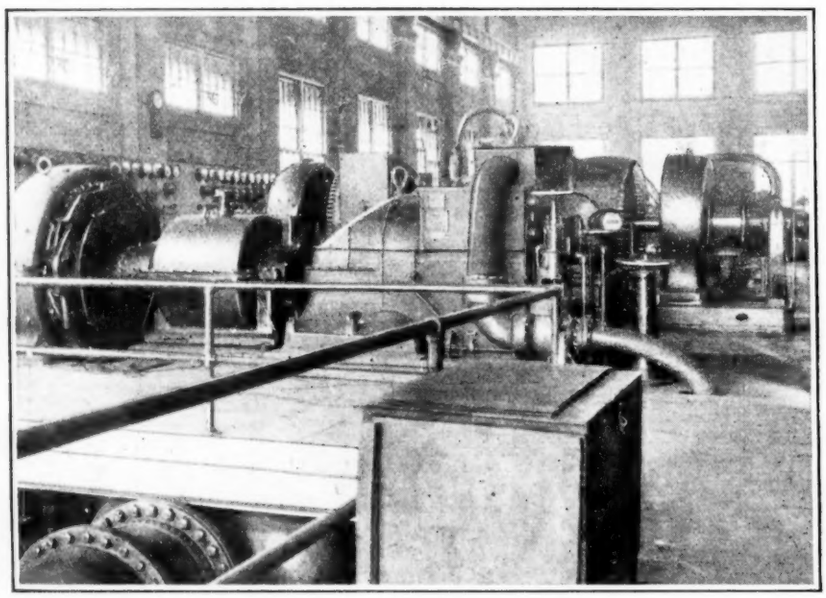

Fig. 1—1,000-kw. mixed-pressure turbine

When these shops were built in 1907, the initial installation of power-plant machinery consisted of three steam turbines direct connected to 500-kva. alternators, one 2,000 and one 4,000 cu.ft. per min. steam-driven air compressors and various pumps. To serve these units, seven 3,870-sq.ft. vertical water-tube boilers were installed, operating at 150 lb. pressure and 50 deg. superheat. Two 300-kw. 250-125-volt three-wire direct-current generators directly connected to induction motors completed the generating equipment serving the shops.

The question naturally arises as to the necessity for installing such motor-generator sets. At the time of the building of the shops alternating-current equipment for cranes and variable-speed tools had not reached the fine stage of development that it has today. Consequently, the motor-generator sets were installed to supply current to the direct-current motors operating cranes and machine tools. The excitation was originally obtained from two 40-kw. 125-volt generators directly connected to vertical single-acting steam engines. One of these has been replaced with a 20-kw. motor-generator set.

Initially the water supply was obtained from a number of deep wells, this supply being used for the condenser cooling water as well as for general purposes. After a year or two of operation the wells played out and it was necessary to operate the steam plant non-condensing and to arrange for a new water source, which was obtained from a public utility.

The demand on the plant's generating equipment gradually outgrew its capacity, three more 3,870-sq.ft. water-tube boilers were installed, and considerable energy was purchased from the public utility. A great amount of the purchased electric power was used for operating a motor-driven air compressor.

In 1924, after making a study of the situation, the railroad officials decided to install a mixed-pressure turbine direct-connected through a gear drive to a three-wire direct-current generator, removing one of the 500-kw. alternating-current turbines. Its steam supply was to be obtained from the exhaust of the two 500-kw. turbines and from the steam-driven air compressors. The unit installed has a capacity of 1,000 kw. when working with a steam pressure of 2 lb. gage and 27 in. vacuum. The steam consumption of the unit is such that the amount of cooling water available gives about 27 in. of vacuum. The mixed-pressure type was selected because of the greater flexibility obtainable with this arrangement. In winter exhaust steam is used for heating, and if there should be a shortage of exhaust steam, live steam is automatically supplied.

The original surface condensers purchased in 1907 were retubed and used, by placing them in parallel and connecting the inlets with a special U-shaped fitting. These condensers are so arranged that either one or both may be used. The Edwards air pumps are also used, but merely as auxiliaries, the condensate being removed by a modern centrifugal condensate pump and the vapor by means of a steam-air ejector.

COMPARISON OF POWER OUTPUT AND COAL CONSUMPTION

	1923-24 Kw.-Hr.	Coal, Tons	1924-25 Kw.-Hr.	Coal, Tons
September	244,000	4,134	204,800	3,856
October	258,000	4,921	259,750	4,339
November	255,000	5,503	192,140	4,909
December	248,000	5,678	259,575	5,973
January	276,000	6,847	281,575	5,778
February	221,000	5,449	242,275	5,151
March	226,000	5,861	228,850	5,106
April	183,000	4,727	234,825	4,234
	1,911,000	43,120	1,903,790	39,346

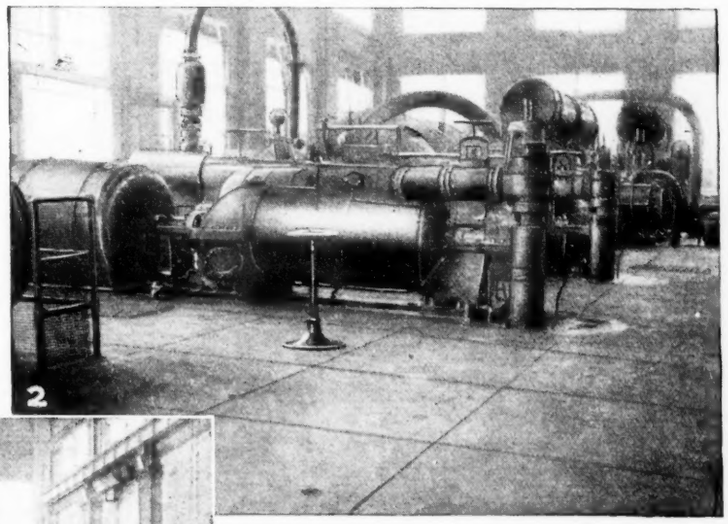

Fig. 2—Two 500-kw. alternating-current turbo-generator sets were retained, while the third was removed to make place for the new unit

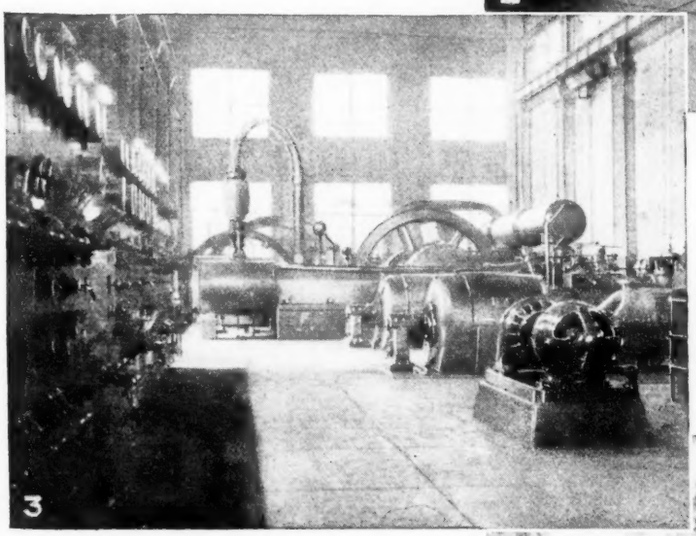

Fig. 3—The air compressors have compound steam cylinders and compound air cylinders

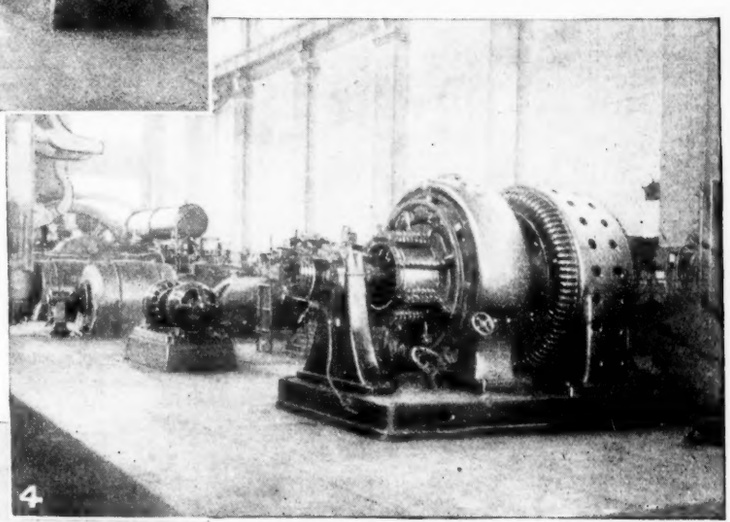

Fig. 4—The motor-generator set supplies direct current to the shops when the heating load is on the system

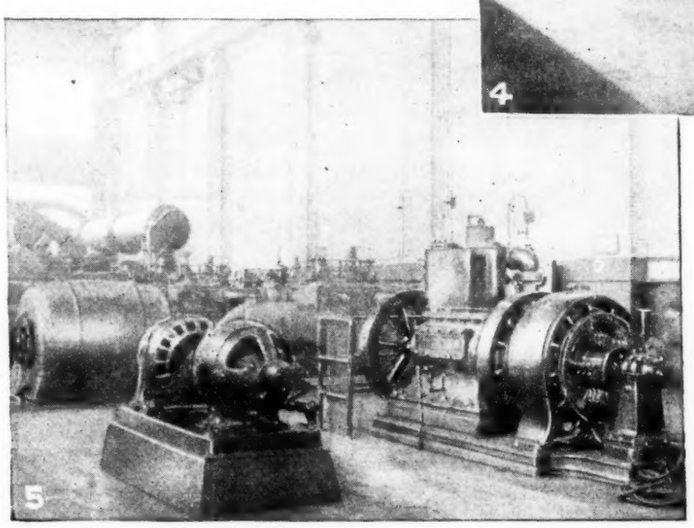

Fig. 5—One of the old single-acting engines driving an exciter has been replaced by a motor-driven generator

Water being scarce and costly, the problem of cutting down the operation costs consisted first in securing a means for recoolin the water for the condensers. This was met by the installation of a cooling pond at the rear of the power-plant building.

The pond was built in 1924 and not only serves as a spray pond for furnishing circulating cooling water to the surface condensers, but also supplies the jacket cooling water to the air compressors and the water used for general purposes about the shops. The makeup control is so arranged that a pilot tank located in the power house and containing a float for operating a valve, allows city water to be admitted to the suction line of the circulating pumps, thereby giving the condensers the advantage of the low-temperature water.

The accompanying table shows the amount of coal used by months from September, 1924, when the new mixed-pressure turbine was installed, to April, 1925, and the tons used for a similar period in 1923-4 before the installation of the new equipment. The electric load also shown for the same periods indicates that the difference in the load on the plant is negligible. It is not to be understood that the coal consumed was used only for the generation of steam for electric power, for the steam for the air compressors and for other purposes was also obtained from the coal shown as consumed. However, it has been found that the electric load is a fairly good criterion for the rest of the load.

As to the final results obtained by the installation of the mixed-pressure turbine, with the same load, 8.75 per cent of the coal has been saved, and a reduction of 88 per cent in the purchased power, all of which amounts to $23,000 for an eight-months period, or $34,000 for the year.

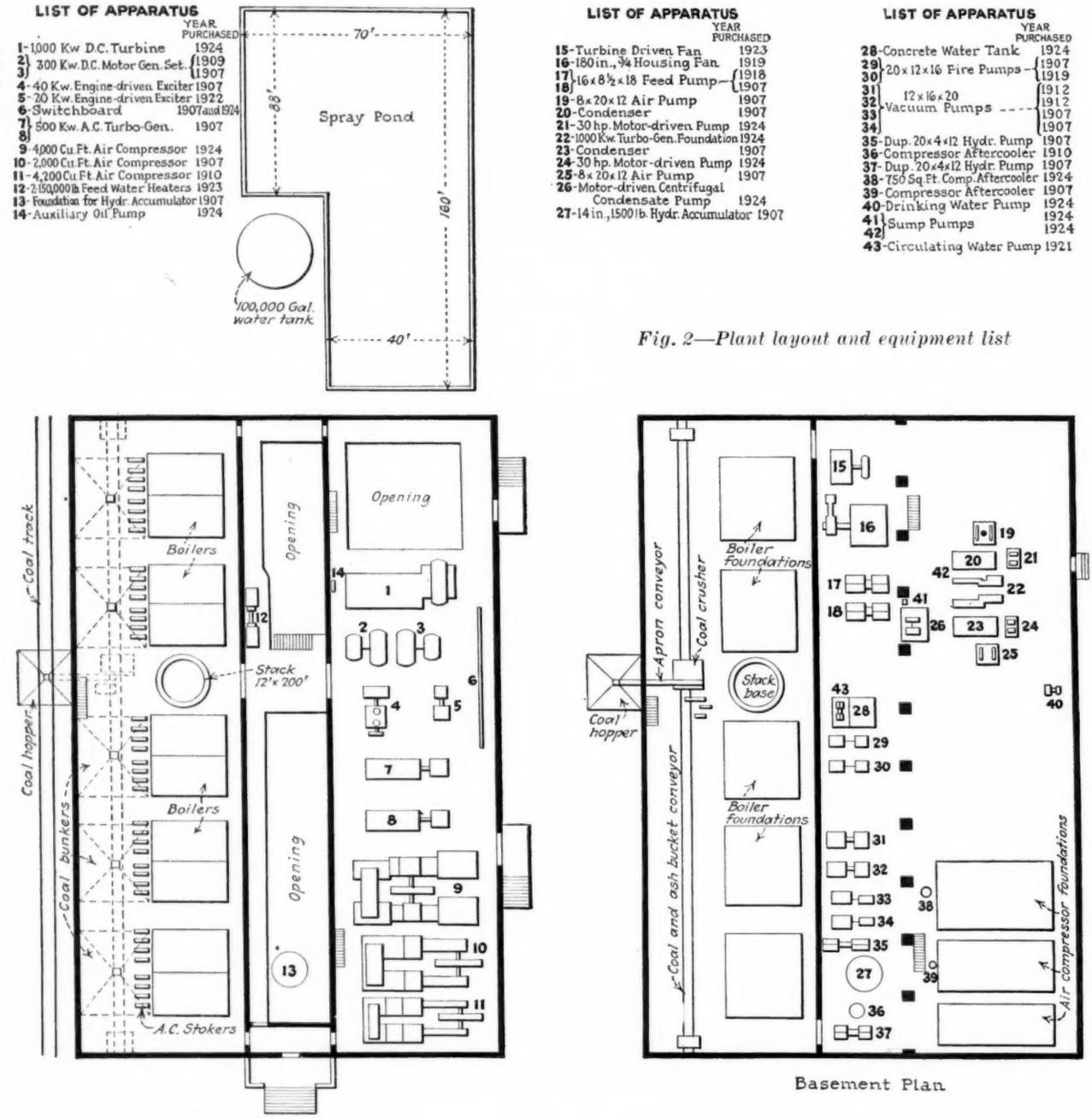
LIST OF APPARATUS
1-1,000 Kw D.C. Turbine 1924
2} 3 300 Kw. D.C. Motor Gen. Set. 1909 1907
4-40 Kw. Engine-driven Exciter 1907
5-20 Kw. Engine-driven Exciter 1922
6-Switchboard 1907 and 1924
7} 8 500 Kw. A.C. Turbo-Gen. 1907
9-4,000 Cu. Ft. Air Compressor 1924
10-2,000 Cu. Ft. Air Compressor 1907
11-4,200 Cu. Ft. Air Compressor 1910
12-2-150,000 lb. Feed Water Heaters 1923
13-Foundation for Hydr. Accumulator 1907
14-Auxiliary Oil Pump 1924
70'
85'
Spray Pond
180'
100,000 Gal. water tank
40'
LIST OF APPARATUS
15-Turbine Driven Fan 1923
16-180 in., ¾ Housing Fan 1919
17} 18 16 x 8½ x 18 Feed Pump 1918 1907
19-8 x 20 x 12 Air Pump 1907
20-Condenser 1907
21-30 hp. Motor-driven Pump 1924
22-1000 Kw. Turbo-Gen. Foundation 1924
23-Condenser 1907
24-30 hp. Motor-driven Pump 1924
25-8 x 20 x 12 Air Pump 1907
26-Motor-driven Centrifugal Condensate Pump 1924
27-14 in., 1500 lb. Hydr. Accumulator 1907
LIST OF APPARATUS
28-Concrete Water Tank 1924
29} 30 20 x 12 x 16 Fire Pumps 1907 1919
31} 32} 33} 34 12 x 16 x 20 Vacuum Pumps 1912 1912 1907 1907
35-Dup. 20 x 4 x 12 Hydr. Pump 1907
36-Compressor Aftercooler 1910
37-Dup. 20 x 4 x 12 Hydr. Pump 1907
38-750 Sq. Ft. Comp. Aftercooler 1924
39-Compressor Aftercooler 1907
40-Drinking Water Pump 1924
41} 42 Sump Pumps 1924 1924
43-Circulating Water Pump 1921

Fig. 2—Plant layout and equipment list

Floor and Ground Plan

Basement Plan

Furnace Ash as a Refractory Material

By HUGH E. WEIGHTMAN
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BRIEF and simple summary on refractories, giving materials used, reasons for failures, and reactions in the brick and the fuel. Specific mention is made of ash as a refractory for patching, its preparation and results of tests of the ash mixtures.

TOO OFTEN a furnace is constructed and then allowed to operate without regard to the life of the linings. The use of cheap clay in construction with good brick often has lessened the life of the furnace. Some periodical repair has been attempted, after a fashion, but it seems that the user is not taking proper advantage of his opportunities. It is not customary to allow a bearing in a machine to run until the oil is used up and the bearing dry. Reasoning along the same line, furnace walls should not be allowed to become full of cracks and badly grooved. Maintenance of furnace structures should be continuous.

Every time a furnace is down, it should be inspected, and it is preferable to install some observing device, so that the interior may be inspected while in operation. It is as important to remove a boiler from service for signs of refractory decay as to cut one out for impending tube failure. Any means for observation should be such that continuous observation may be made. Opening a door for this purpose and using a colored glass is not acceptable practice. Aside from the introduction of cold air it is impossible to hold an observation glass steady enough in the flood of heat to make accurate observations.

The foregoing paragraphs may seem to be afield from an introduction to refractory materials, but the thoughts given are essential to a groundwork for the complete understanding of the situation. There are more of such constructive details to be taken into account, but these are more generally known.

The Most Important Materials Are the Shapes

In boiler-furnace refractories the most important materials so far as quantity goes, are the shapes, that is, brick and tile. Next in order are the cements and patching materials. Some furnaces have been constructed of the prepared plastic clays and grogs into a solid mass without joints. This type of construction has been used to a considerable extent in small units. Its objection in large units, in the author's opinion, is the difficulty of properly maturing the mass. If such materials are porous enough to resist the spalling strains, trouble is encountered in the fluxing of the walls. If the refractory is built to resist the fluxing, it will not mature properly. After all, to mature a refractory properly, it must be subjected to a uniform heat, preferably higher than the working temperature of the furnace in which it is to be installed. This temperature must penetrate throughout the section. It is obvious that this uniform penetration of heat cannot be had where the wall is constructed *in situ*, neither can a higher than normal burning temperature be applied.

Refractory materials in general are either predominantly of silica or alumina, or combinations of either. Silica is seldom applicable to boiler furnaces, as it spalls badly when allowed to cool below a red heat. Further, silica is badly corroded by the ferric and calcic constituents of the fuel. Sulphur also has a bad effect on silica. Alumina recently has played a large part in the production of super-refractories. It has the disadvantage of high cost and owing to its weak combining qualities has a tendency to shift from one combination to another. In other words, very high alumina refractories tend to be unstable. It is possible to stabilize the alumina by combination with other oxides. For this purpose, zirconium has been used, but in addition to being expensive, it creates a liquid flux when attacked by fuel slags. Titanium and iron have been used with much success in creating a viscuous refractory, especially in service where it is attacked by fuel slags.

The so-called basis materials, magnesite, dolomite, etc., have not found application in boiler furnaces on account of their fragile nature. This is true of chromium compositions. Silicon-carbide, while resistant, is not generally applicable from an economic viewpoint.

The bulk of the furnace work is set with firebrick of the usual sort where the silica and alumina are almost evenly divided. As most operators are familiar with firebrick, nothing further will be said about its composition.

With such a wide variety of materials to choose from, it is still a hard matter to secure freedom from expensive repairs if the work is pursued in the customary manner. Without considering any one particular material, the following facts should be kept in mind and the work done with these in view.

Maximum Furnace Temperature Less Than 3,000 Degrees

A survey of the power plants throughout the United States discloses that the maximum furnace temperature as properly recorded by the pyrometer is less than 3,000 deg. F. As far as heat alone is concerned, any of the usual refractories will withstand this heat without mechanical load. All high-grade firebrick will withstand a load of 10 to 15 lb. per sq.in. under this temperature. High-grade flint brick, dry pressed, with little if any plastic clays, will take loads up to 25 lb. per sq.in. at this temperature without failure by squatting. However, in practice these brick have short life, considering their melting point with reference to the actual furnace temperature.

The reason for the failure to stand up under present-day operation is due chiefly to a reduction in melting point by fluxing with the fuel constituents. The problem then of better refractory life is one to reduce this fluxing action. Preventing the penetration of ash slag by dense brick is open to the objection of reduction in

strength to resist spalling. For mechanical reasons the texture of the wall should be coarse. This should be the case also to prevent spalling. The way open to increase the resistance to fluxing and at the same time maintain a good mechanical structure is to construct the shapes of a coarse-textured material, formed under high pressure (2,500 lb. per sq.in.) with as little plastic material as possible; and then, coat the furnace interior

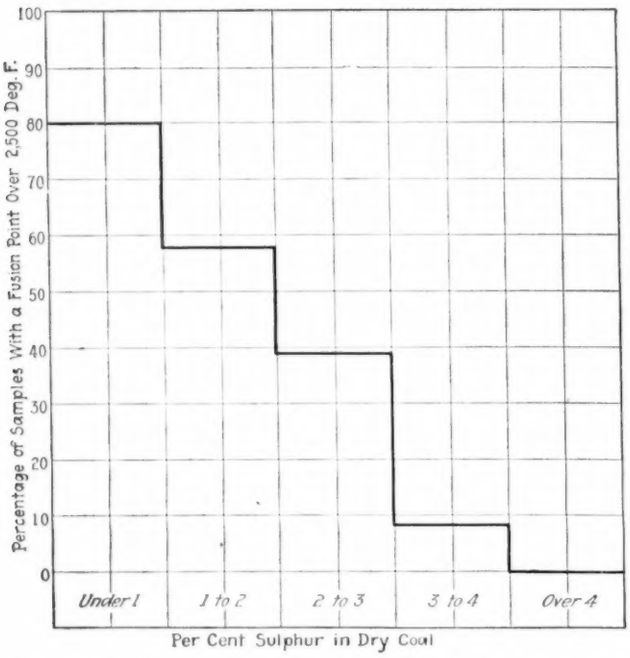


Fig. 1—Effect of sulphur on fusing temperature of ash

with a refractory wash. The function of the wash will be to act as a neutral body to the combination with either the firebrick or the slag.

This is not an easy wash to make and should be attempted only by those who know what the limitations are. The wash must be unattacked by the slag or only slightly attacked. For extreme conditions, refractoriness alone will not suffice. A material to stand up as a wash under these conditions must not flux, therefore it should not be made so that it can be applied in thick layers. It must be applied thin and often; the more frequently the better.

Patching Spots Necessary

Brick fails at spots in a furnace, and it becomes necessary to patch these spots, since the wash cannot possibly be of use in this work. The patch should be made of material of the same general nature as the brick it is replacing. It must be pounded in place in small bits at a time. It should be dry enough to allow hard pounding without squeezing around the mallet. This patch must be matured by heat before it is covered by an impervious wash; otherwise the wash will peel off and the patch will be disrupted by the pressure of the sealed moisture. The wholesale throwing of patching materials on a furnace structure is by no means an effective method whether done by mechanical means or by hand. Patches should be applied only to small sections. If the furnace needs a large amount of patching, it will be found cheaper to install new brick. As a rule the material and labor costs for large sections of furnace repair by plastic means is four times that of good brickwork. The cost per hundredweight of patching material is not the criterion, but the cost of the material as equivalent to a unit number of brick.

Ash as Refractory for Patching

It is with the same idea of making a more satisfactory and at the same time cheaper product for patching that the study was made of coal ash.

The typical analysis of ash from different coals does not show any more difference than the analysis of clays used in the manufacture of firebrick. The usual range is as follows: Silica, 40 to 60 per cent; alumina, 20 to 35; ferric oxide, 5 to 25; calcium, 1 to 15; magnesium, 0.5 to 4; sodium and potassium, 1 to 4; sulphur, 0.1 to 4 per cent.

Before outlining some of the methods for selecting the ash and its treatment, it is necessary to point out a number of simple reactions that occur in both brick and fuel with respect to the melting of the material. As a general rule, if two materials of high melting point, whether equal or unequal, are united and fired, it will be found that the combination has a melting point much less than either of the component materials.

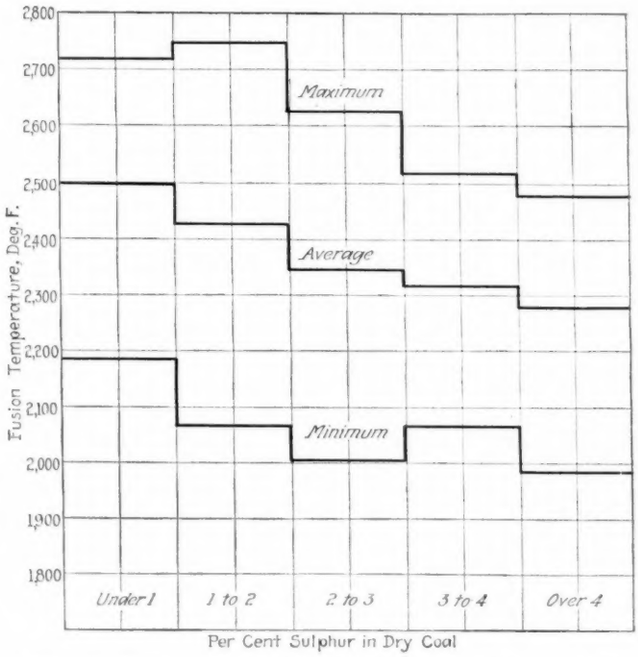


Fig. 2—Range of fusion temperatures with varying percentages of sulphur

If the materials just fused at a given point are reground and again fused, it will be found that the second fusion generally will be lower than the first determination.

Each heating results in a more homogeneous mixture, a more complex silicate. In the manufacture of refractories several combinations are put together, fired to a given temperature for a sufficient time for certain reactions to take place. When the reaction is completed, not wholly, but sufficiently in the judgment of the maker, the body is cooled to arrest further reaction. If in use the body is not operated at temperatures as high or nearly as high as the final burning temperature, the reactions will not again start unless by the action of impinging solids from the fuel. As the market will not pay the price for refractories burned with sufficient fuel and time to attain a sufficiently high temperature,

the operator must be content to have brick in which the reactions begin to complete themselves during their life in the furnace. As the reaction follows the exponential law in its growth and as the exponent has a negative constant, the reaction becomes slower and slower as it approaches completion. Long before completion the refractory has ceased to be serviceable.

Refractories made of simple silicate are easily combined with slags. Where extreme temperatures are not met with in practice, as in boiler furnaces, it is possible to use some of the less refractory silicates. These more complex silicates, though having a lower melting point, are far more stable and less liable to form combinations with the slag. It is for this reason that ash often lends itself to composition as a refractory material. A small number of hand-made brick have been constructed with success, though the bulk of the experiments were with ash as a patching material. Except in unusual cases, the ash combinations do not make good protective washes, such as were mentioned in the fore part of this paper.

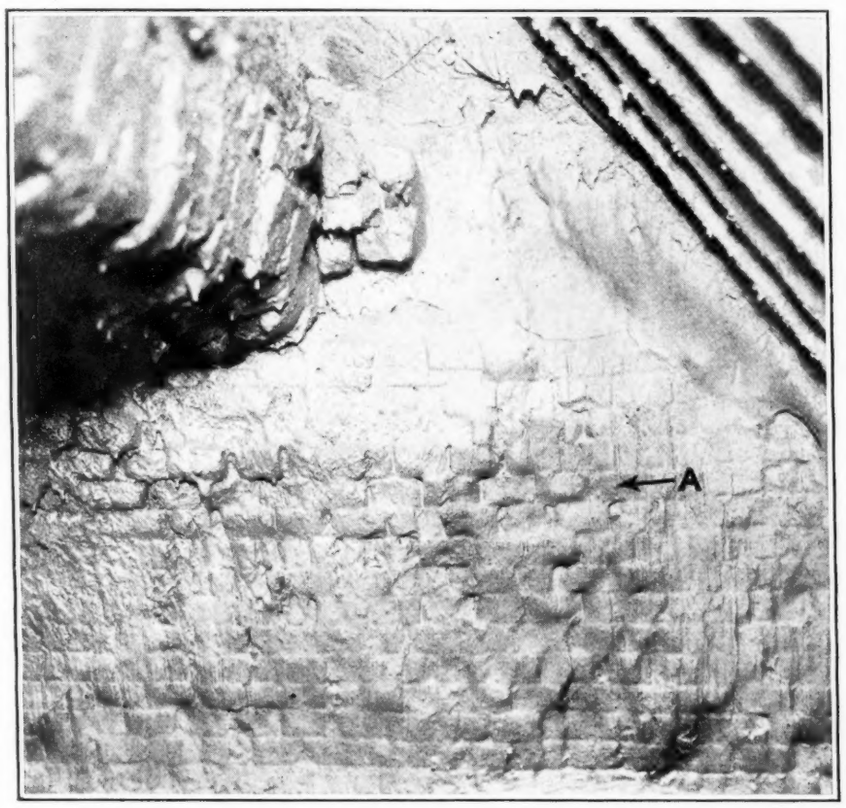


Fig. 3—Photograph taken after three months' operation at 176 per cent rating. Course A set with firebrick alternating with brick made of ash

One of the first requirements of ash as a patching material is that it be sufficiently refractory, or capable of being made so. To begin with, ash should have a primary fusion point of 2,500 deg. F. or better. Ash of lower fusion point can be used in some cases.

J. A. Murray, chemist of the Detroit Edison Co., has shown that sulphur content in coals is a good indication of their probable fusion point. Fig. 1 shows the percentage of samples having a fusion point of over 2,500 deg. F., with different percentages of sulphur content. Fig. 2 shows the maximum, minimum and average fusion points of coals with varying percentages of sulphur. These curves are the results of 1,163 analyses. Sulphur is not the prime cause of low fusion, but it is noticed that iron and sulphur increase and decrease with each other in almost constant ratio in fuels. Fieldner, Hall and Field point out this fact and lay the melting action to the iron content. Since sulphur determinations are simpler than for iron, sulphur content may be used to judge the ash.

From an examination of many refractories, oxides and ashes, the author is convinced that iron as such is not the offender, but the manner in which the iron may be combined. Where iron is in excess of 2 per cent, it is as a rule necessary to examine the ash microscopically to determine how much effect it may have in reducing the fusion point. The introduction of titanium to the amount of one-tenth of the iron as ferric oxide usually will nullify to a great extent the fluxing action of the iron.

If an ash has a fusion point in excess of 2,500 deg. F., it may be used safely in combinations as given hereafter. If it is of lower fusion point, it must be studied chemically and microscopically by one in position to know whether it is possible to raise the fusion point at reasonable cost.

As taken from the boiler furnace, ash contains considerable unconsumed carbon. This is not the disadvantage it might seem. Magnesium in ash varies little from different shipments from the same mines. As shown by the foregoing range analysis, it varies from 0.5 to 4 per cent, with sodium and potassium compounds having nearly the same range. These materials are detrimental to the fusion point of the ash more than the iron, when in combination with iron. Before considering an ash as unfit for patching purposes, try treatment to remove these compounds from the iron.

In selecting ash, remove any large masses of clinker. These as a rule are permeated with a large excess of combustible and alkalies. Have a large porous tank in which to age the ash. A pit usually can be made in a porous soil by lining the hole dug in the ground with a lean mixture of cinder and portland cement, or stone may be used.

Final Treatment of the Ash

Crush the ash selected, put it in the pit and saturate with water. Keep it wetted from time to time and allow the water to percolate through it. A period of three months to a year is sufficient, depending upon the ash. A trial in the laboratory will show when the excess of alkalies has been removed.

After the foregoing treatment, the ash is put through a drying process. This can be done best in the initial stage by spreading it in thin layers in the open air. In fact it is often an advantage, where space is not restricted, to carry on the percolation and drying on

wood floors in the air, as is done in gas works in removing the sulphur from purifier materials.

Next place the material in an oven, or if a large quantity is to be worked, use a rotary drier. A drier of the rotary type, such as is used for drying pulverized coal, is satisfactory for this purpose. The dried ash is then mixed with 5 per cent bentonite. In adding the bentonite several ways are open. If it can be pulverized very fine, it may be mixed mechanically with the ash after the ash is discharged from the drier. If the bentonite loses its hydrating power at a low temperature, the required weight of bentonite may be made into a slip or slurry weighing about 30 oz. to a pint container and this watery slip used in wetting the ash. The mixing may be done in any convenient device such as a concrete mixer. This addition of bentonite will turn the non-plastic ash into a plastic mixture that can be worked easily.

If bentonite is not available, a poorer binder, but one that will work, may be made from a thinly boiled flour paste of one part flour to 20 or 30 parts ash. Wormy or otherwise contaminated rye and wheat flour usually can be purchased at a low figure. If one part molasses to each part of flour be added to the mixture, the results will be improved. In the latter case dissolve the molasses in hot water before adding to the paste.

Any of the combinations mentioned may be kept at the plant ready for use by always keeping a thin film of water over the box in which the mortar is stored.

Brick Should Be Wet Before Laying

When laying brick, wet the brick before starting the job, then dip the entire brick in the mortar and drive in place. Use a thin joint. For patching holes, place a sufficient quantity of the mortar on a board or other suitable place where it may drain without washing away the fines. As soon as the mass is denuded of sufficient water to make it possible to drive it in place with a mallett, proceed with the work. In patching overhead work as in arches, it is often found that the patch will fall of its own weight. In such cases make some "gaggers" of say No. 18 soft iron wire. Anchor the gaggers into the holes to be patched and work the mortar around them. These gaggers ultimately become part of the refractory mass.

After the patching work has been completed, especially if the patches are quite thick, start a slow fire and open the dampers to allow as much excess air as possible into the furnace. Carry this fire until the patches are thoroughly dried out. Then start the fire going more briskly until the temperature is up to normal. All this time burn with an excess of air, for only after a full fire has been carried for about 24 hours should an attempt be made to bring the excess air down to where the CO_2 will be higher than 9 or 10 per cent. If these directions are followed carefully, no part of the patch will be lost nor will shattered work be found when the furnace is examined after its initial run with the new patches.

What has been said with relation to mixture of ash as a patching material, also applies in most cases to the fireclay mixtures offered on the market. With them or with the ash mixture these instructions may be disregarded, but the neat solid surfaces, so often talked about but seldom found in boiler plants, will not be obtained.

In cooling the boiler down with this or any other material, shut the drafts, leave ash on the grates and shut off all sources of air entering the furnace, just as soon as the furnace gets to a red heat. The harm is not done down to that point, but from the red heat down.

Test of the Ash Mixtures

A complete schedule of tests was made of the various mixtures given in the foregoing. There were tests also of mixtures of ash in which special treatment had been given to increase the melting point by the addition of titanium, alumina and other oxides. These tests show that brick can be made that have as good characteristics as regular grades of firebrick. Tests of the mortars as bonding agents show that a good bond can be made as strong in many cases as the brick and in other cases stronger than the brick itself. In such bonding tests, regular firebrick was used, bonded under a load of 2 lb. per sq.in. and at various temperatures. The strength of the bond was tested in shear. Three bricks being bonded together, the outside brick was placed on a stand over an aperture through which the inside brick was forced upon failure by slipping of the bond or fracture of the bricks.

Ash treated as shown here and initially of a melting point of 2,500 deg. F., had a melting point after treatment around 3,000 deg. F. The mixture worked well as a patching material and as a bond, as is shown in Fig. 3. The course marked *A* in the photograph was set with alternate pieces of high-grade firebrick of a well-known make and brick made of the ash mentioned in this paragraph. The ash brick were hand made and probably would have stood up better if made by machine with a heavy pressure. This photograph was taken in the furnace of a 3,500-sq.ft. Stirling boiler after three months of operation at an average rating of 176 per cent.

It is not the purpose of this paper to recommend the use of ash as a brick-making material, although it has possibilities. The paper is written to record progress in the efficient utilization of the waste materials at our disposal. To record much of the data concerned in the tests of the materials mentioned in this paper would unnecessarily prolong the article. It is for this reason that details of the tests, methods for treating various ash encountered in these investigations, and costs of production, with economic figures on the use of the materials, will be given at a later date. It appears from the work done thus far, that much additional study could be made profitably along this line. It is hoped that those in position to carry on large-scale operations in boiler-furnace economy will take hold of this idea and work with it until there are a large number of representative installations. In this way only will all the possibilities be uncovered.

The study of moving objects by intermittent light, or by viewing them through slots in a rotating disk, is one of the oldest tricks of physics, but the field of practical usefulness of the "stroboscope" may be greatly extended. The Sept. 11 issue of *The Engineer* described a new type of stroboscope called the Rotoscope. This is a binocular instrument resembling a small stereoscope. The object is viewed through slits in a rotating cylinder, which gives two glimpses per revolution and is driven at any desired speed by clockwork or an electric motor. This instrument has already been applied to problems as diverse as the motion of a turbine shaft and the wing movement of a dragon fly.

Erecting Vertical Waterwheel Generators

By N. L. REA
Contract Service Department, General Electric Company

A CONSTRUCTION engineer of wide experience gives many valuable suggestions on how to avoid erection difficulties and describes a number of useful methods for checking the location of the different parts of the machine.

THERE are many ways of erecting generators, and it would be a foolhardy man who would attempt to give them all or say which was best. This article will, therefore, give one of the ways without any claim to its comparative merits. It is not intended to give complete details of the erection; these are best obtained from the manufacturer's instruction books, but some of the short cuts and kinks used in the erection will be discussed.

Assume that the machine is a vertical waterwheel alternator rated at about 1,000 kw. and has a lower

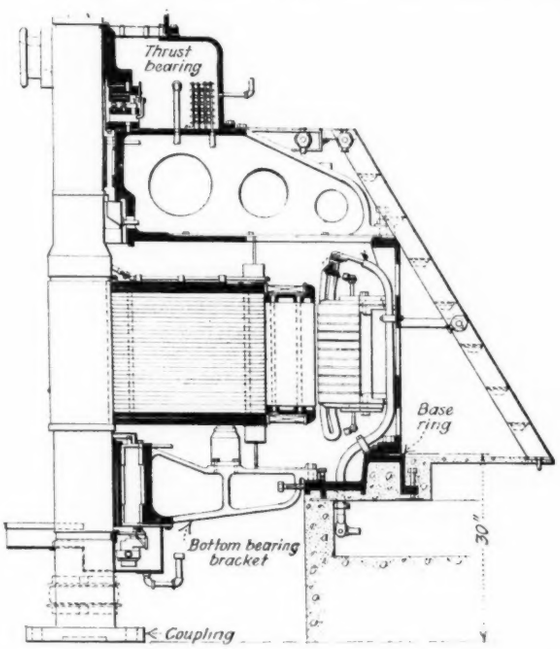
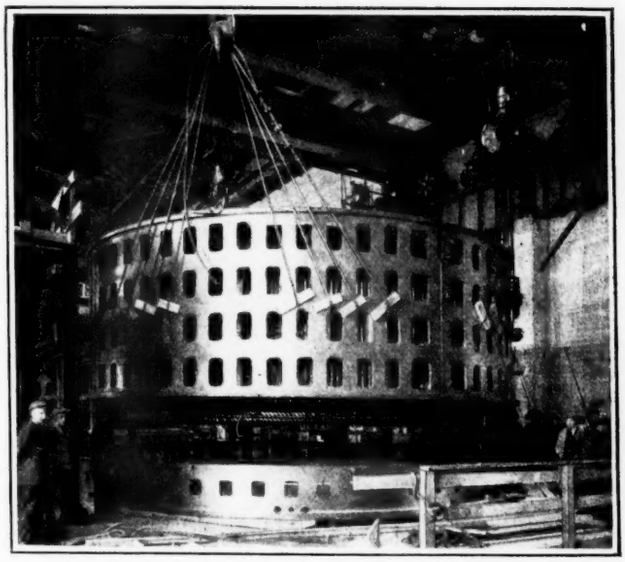


Fig. 1—Section through vertical waterwheel generator

guide bearing and combined thrust deck and upper guide bearing housing and a thrust bearing, a cross-section of which is shown in Fig. 1. The waterwheel is already erected and leveled, and the runner will have to be raised $\frac{5}{16}$ in. to the running position. At present the runner is resting on the speed ring and supports the waterwheel shaft.

From the outline drawing of the generator the ver-



Placing stator of large waterwheel generator on its base ring

tical distance between the top of the generator base ring or sole plates and the face of the generator coupling is found to be, say 30 in. Then the base ring or sole plates must be set $30 + \frac{5}{16} = 30\frac{5}{16}$ in. above and concentric with the waterwheel coupling. The elevation of the top of the base ring or the sole plates is not of so much interest as is the location of the top of the armature frame. This carries the thrust deck and must be right. If the sole plates or the base ring are set and grouted in first and there are any errors in the machining of the alternator's frame, the erector might be out of luck. The chances of this are remote but it can happen, and the erection man early learns to be from Missouri.

The surest way of keeping out of difficulty is to set the base ring or sole plates somewhere near right with a tram and then set the armature in place before doing any real leveling or centering. The generator drawings will show the assembly line of the machine, and the base ring or sole plates must be placed so the generator leads and oil piping will match with the locations shown on the building plans.

Retaining the Clearance in the Bolt Holes

The bolts holding the bottom bearing bracket and the armature to the base ring or sole plates usually have $\frac{1}{8}$-in. clearance. This is intended for the final adjustments during erection or for future adjustments due to foundation changes or wear. It behooves the erector, therefore, to save this movement for future use. Many an erector has found, to his sorrow, that two bolts that touched on opposite sides of the holes robbed him of all the adjustment. Chipping out holes or turning down bolts is not an easy job, so it is a wise plan to make sure of the clearance. This can be done by cutting some strips of sheet iron that is about $\frac{1}{16}$ in. thick and a little shorter than the circumference of the bolts, form them around a bolt and drop one of these collars in each bolt hole.

The bottom bearing bracket and the armature will be bolted to the base ring or sole plates with these collars in the holes, and they will be taken out after the machine has been grouted in position.

Assume the armature resting on the base ring or sole plates somewhere near its final position and ready to make the final adjustments. The armature frame is, say, 36 in. high, then the top of the frame must be $36 + 30 + \frac{5}{16} = 66\frac{5}{16}$ in. above and concentric with the waterwheel coupling. Have the blacksmith make a

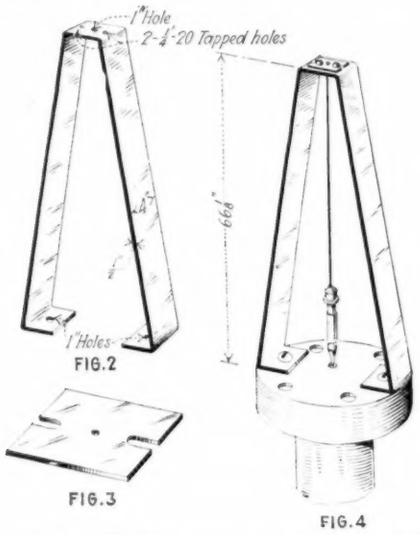


FIG. 2

FIG. 3

FIG. 4

Figs. 2 and 3—Device used in centering generator around waterwheel shaft

rough forging of whatever heavy bar stock he has on hand, like that shown in Fig. 2. This preferably should be ½ or ¾ by 3 or 4 in. stock, as it should be something that is rigid. The relative shape does not matter much except that the bottom holes should be separated by the diameter of the waterwheel coupling bolt circle and the forging should be narrow enough to come up through the lower bearing housing with ample clearance.

A piece of ¼-in. brass plate about 4 in. square as shown in Fig. 3, is required to go on top of the forging. This plate has two slots about ⅝ by 1 in. long, as shown, and the hole in the center is just the size of the oiled-silk plumb line. This plate is fastened to the top of the forging with two machine screws and the outfit put on the waterwheel coupling as shown in Fig. 4. Shims are placed between the feet of the forging and the coupling until the top of the brass plate on the forging is just $66\frac{5}{16}$ in. above the face of the coupling. This is all right if there are adjusting shims under the armature frame and the measurements allow for these shims. If no shims are provided, it will be better to see what sheet metal is available and set the forging two or three shims lower than the drawings call for or, better still, insert two or three thicknesses of shims between the armature and the base ring or sole plates. If the machine has a base ring, make the shims the same width as the ends of the thrust deckarms and put a set between the generator frame and base ring directly under the ends of the thrust-deck arms and shims around every holding-down bolt. If the machine has sole plates, fit a set of shims to each sole plate.

The erector may make a slight error somewhere, or the waterwheel manufacturer may want to try a lower setting of the runner so it is well to have a little range of up-and-down adjustment. It is a difficult job to chip, file and scrape sole plates after they are grouted.

After the forging is set at the proper height and bolted rigidly, adjust the brass plate until the plumb bob is directly over the center of the waterwheel coupling and lock the plate in place with the machine screws.

Now proceed to set the top of the armature to the brass plate on the top of the forging. The hole for the plumb line will serve very well as a center for a tram. The tram will not only serve to set the armature, but will also check the armature to be sure it is round. Light or large diameter frames may get out of round owing to changes in casting strains after machining and have to be jacked into shape and held by the grout under the base.

Some machines have a square shoulder for the ends of the thrust-deck arms. Others may have the center line of the thrust-deck bolt holes plainly marked. It isn't safe to tram to the inner edge of the top of the generator frame if this surface is rabbetted. If there is no other way, screw the thrust-deck bolts home and tram against the inside of the bolts just above the threads.

Setting the Top of the Armature to Elevation

The next and by far the most important step is to set the top of the armature level and to the proper elevation. The best method of accomplishing this will be determined by the size of the machine and local equipment and conditions. By size is meant the physical dimensions rather than kva. rating. For the smaller-sized units a straight-edge and a high-grade level probably make the best arrangement. The straight-edge does not need to be from one of the big toolmakers and guaranteed to a very high degree of accuracy. A wooden straight-edge made by a first-class carpenter will give accurate results, for the reasons hereinafter set forth.

A good carpenter's level will often save time. It can be used to make the preliminary settings and then the high-grade accurate level for the final adjustment. The carpenter's level comes to rest much quicker than the

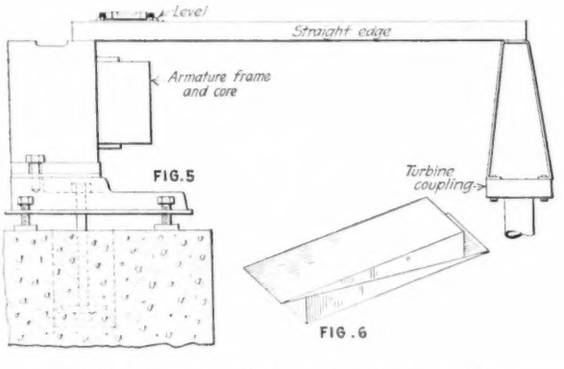


FIG. 5

FIG. 6

Fig. 5—Method of leveling generator to the correct elevation. Fig. 6—Wedges used for leveling generator

more accurate one and there isn't as much danger of injuring it, especially if the preliminary adjustments are made by some of the younger men on the job and the final setting made by the erector in charge.

Fig. 5 shows the way the straight-edge and level are used. The level is fastened to the straight-edge and the same end of the straight-edge kept on the center plate over the waterwheel coupling. The other end of the straight-edge is swept around and the armature adjusted until the level bubble is in the center. It is well to test directly over each sole plate or where the

end of each thrust deck arm will later rest on the armature frame.

Sweeping the straight-edge around in this way will insure the armature is level and any error in the straight-edge will simply mean that the whole armature is high or low by the amount of the error. If one end of the straight-edge is used for one side of the armature and the other end for the other side, the armature would be out of level by twice the error of the straight-edge.

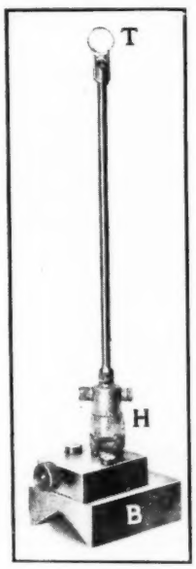


Fig. 7—Leveling target

After the armature shows level, the straight-edge can be checked by turning it end for end and again checking around the armature. The amount of shims necessary to bring the level bubble to the center will show how much, if any, the armature is off the elevation. If the forging on the coupling is low, the armature is high and vice versa. Having the armature level is the important thing, and a few thousandths of an inch high or low is usually not a serious matter. Many of the present-day generators have jack bolts in the base ring or sole plates, and these make for quick, accurate work in leveling.

When these are not provided, the erector must fall back on the old-fashioned wedges. Nearly every erector has his own ideas as to the best length, size and taper of wedges. In general it is better to have too many rather than too few wedges, space them uniformly and drive them evenly. Two wedges used as shown in Fig. 6 will give better results than a single wedge. If there is only one machine to be erected, the local blacksmith will turn out the wedges quickly and cheaply. If the installation involves several machines, a considerable saving can be made by adopting wedges of the same size for all the equipment and having them made from cast iron at a local foundry.

Preparing the Surface of the Foundation

The surface of the foundation should be roughened if necessary to give a good bond with the grout, and there should be at least an inch of grout under the bottom of the sole plates or base. The foundation should be absolutely free from dust and dirt and thoroughly wet down before the grout is poured. The grout should come up inside the base or sole plates at least an inch above the top of the lip to give a good bond, and it is preferable to fill them full. Even the heaviest box-section bases are intended to act simply as liners between the machine and the true foundation, and the grout must thoroughly tie them together.

On large machines it is practically impossible to get satisfactory leveling with a straight-edge. Another method has been developed that gives results of surprising accuracy. Three men have made independent checks on an armature 37 ft. in diameter and come within two or three thousandths of an inch of the same level. This device is shown in Fig. 7 and consists of a base *B* that has a veed bottom so it can be used on horizontal shafts, a standard inside micrometer head *H* with rods and a special target *T*. The target ring has two three-mil wires stretched across it. These wires are at right angles to each other and the pair are 45 deg. from the vertical. In use, a white paper with a light behind it is held back of this ring, which faces a wye level, and the angles between the target wires bisected by the cross-hairs of the instrument. Experience has shown that the blind spot back of the cross-hairs in a wye level may be several thousandths wide, which makes the use of a horizontal wire or line on the target inaccurate. With the new method the erector is working with two silhouettes against a light background and the angles can readily be bisected within one or two thousandths of an inch.

When the armature has been properly set and before grouting, it is a good plan to have the elevations checked by the resident engineer, the waterwheel erector and the general erector. A memorandum should be drawn up, using values that all three agree on, three copies made and signed by all three men, each to keep a copy. The form of memorandum is as follows:

MEMORANDUM

Date
Location

We the undersigned have this day checked the alignment of unit No. ———, generator No. ——— in the power house with the following results:

It is on the center line of the building within ——— thousandths.

It is on the cross center line within ——— thousandths.

It is central with the waterwheel coupling within ——— thousandths.

It is to elevation within ——— thousandths.

It is level within ——— thousandths.

This memorandum not only gives a permanent record and reference in case of foundation changes, but also prevents any tendency to "pass the buck" in case trouble develops later.

If the base or sole plates are provided with anchor bolts, run a little grout in the bottom of the pockets to lock the bottom of the bolts before making the final checks. The bolts can be set up snugly against the jack bolts or wedges under the base ring or sole plates, and there is less chance of the machine's shifting before the grout is poured and set. After the final check the machine should be grouted and the grout allowed to set hard before the assembly is completed.

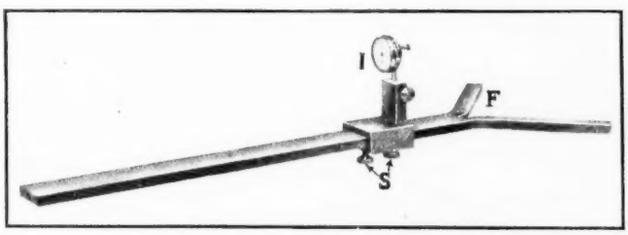


Fig. 8—Gage for checking alignment of generator and waterwheel couplings

On small machines almost any good cement will do, but on very large diameters it is better to use old cement. Cement heats on setting and the amount of heating is proportional to the speed of setting. This heating may be enough to heat the castings and cause expansion. The grout sets hard and there may be considerable strain when the castings cool. This is more likely to cause trouble with the wheel parts that are completely grouted in and rarely gives trouble with the electrical equipment. It is well to keep it in mind,

however, and to arrange for fairly slow-setting cement. Don't let the grout come high enough to prevent shifting the armature on the base ring or sole plates. Cases are on record where the grout came up through the gaps in the bottom of the armature frame. To remedy the difficulty, the armature had to be lifted and the grout chipped away to allow shifting for the final adjustment.

The joint coils can be put in winding while the grout is setting if the armature was shipped in sections. The collars around the holding-down bolts of the armature and the lower bearing bracket can also be removed. The rotor can now be put in place, and thrust deck and the upper guide and thrust bearing assembled. In assembling the upper structure of the machinery, use extreme care to prevent any oil leaks or seepage. Leaks will feed oil into the rotor and the oil will be thrown into the windings, where it is bound sooner or later to cause serious trouble.

Preventing Oil Leakage

If the thrust deck is split, be doubly careful to prevent oil leakage. If there is the least doubt as to the proper method of assembly, ask the manufacturers for advice and instructions. Few erectors know that cast steel or cast iron can be tinned and soldered with ordinary soldering salts and soft solder. The surface must be cleaned and a large hot, well-tinned soldering copper is required. After the thrust deck has been bolted together as instructed by the manufacturer, boiling the bolts and setting them up while hot helps a lot in getting a tight joint. After this has been done, cut a shallow groove all along the joint on the top of the thrust deck inside the space inclosed by the thrust-bearing housing. A three-cornered scraper and file will do this very nicely. Tin this groove, fill it with solder and scrape the solder down level with the top surface. This gives additional assurance that the joint will be tight. If there are any spots that look porous inside the thrust-bearing housing, tin them over while the soldering iron is handy.

Too much care cannot be exercised to prevent oil leakage. Either tin and sweat all joints in the oil piping or use some pipe-joint compound that it is known will hold hot oil and stay tight. Shellac gets brittle and fails in time. Some of the bakelite compounds are better and some erectors use the following mixture: Cut ordinary shellac in alcohol. Take one part of the liquid and two parts pure pine tar, mix and boil slowly for two hours. Thin this mixture with ordinary shellac as needed. This compound does not get brittle and holds well.

Checking Coupling Alignment

After the weight of the revolving field has been transferred to the thrust bearing from the assembly blocks or the combined brakes and lifting jacks under the rim, set the lower bearing bracket to the shaft with inside micrometers or by the use of a pin and feelers, and assemble the bottom bearing. The height of the rotor should be such that the spigot or plug on the waterwheel half of the coupling just clears the face of the generator half of the coupling.

The machine is now ready to make the final setting of the generator and the waterwheel. The faces of the coupling must be parallel and they must line up before the holes are reamed and the bolts fitted. A small parallel block and a set of feelers gives a ready means of checking the faces. In days gone by a box rule or a straight-edge and feelers were almost universally used for checking the line-up of the two halves. This, however, was slow work.

A new device has been developed to overcome the difficulties with the old method. One form of this tool is shown in Fig. 8. In using the device the forked end *F* is slid in against the spigot with the indicator *I* turned toward the half coupling that carries the spigot. Loosen the setscrews *S* and slide the block in gently until about a half-scale reading is obtained on the dial, then lock the block and walk around the shaft. This test tells if the spigot and the outside of the half coupling are concentric. They ought to be, but once in a long time they are not, so it is wise to make the check. If this check is satisfactory, turn the outfit over and check the lineup. The dial test indicator will show the amount and direction the generator must be moved to align the two halves.

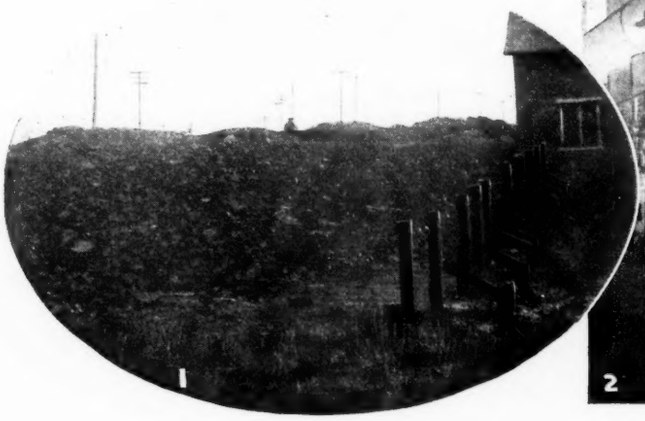
A pointer on the movable block, Fig. 8, will give very good results with feelers, if a dial test indicator is not available. A piece of ¼- or ⅜x2-in. bar steel will do very nicely for the Y-bar, and the movable block may be anything from a piece of the same material bent at right angles and held in place by a small C-clamp or a couple of stove bolts through a slot in the Y-piece, to an elaborate piece of the toolmaker's art. A "handy man" can knock one together in a few hours from material dug out of the scrap pile, or he can put in several "rainy days" making a real tool that will be a part of his regular equipment.

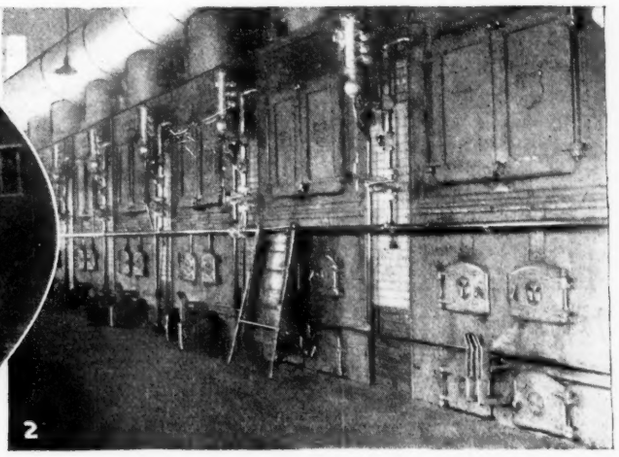
Hydro-Electric Power in New Zealand

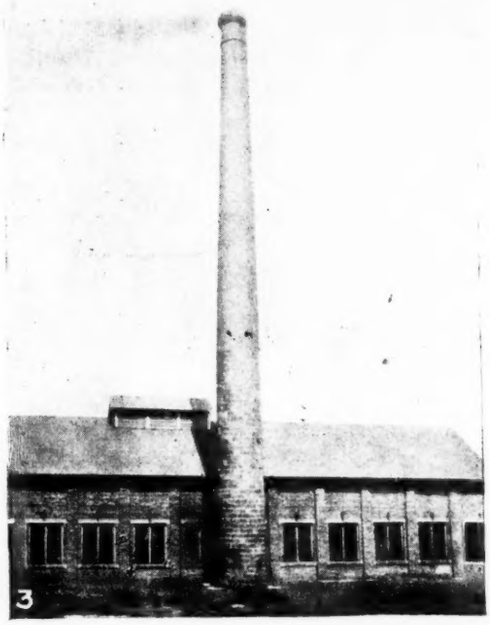
New Zealand, a country of 110,000 square miles and 1,300,000 people, is favored with an abundance of water which flows in many streams, some of them large and swift. There is also plenty of coal of good grade for many years to come. Until comparatively recently, the country was somewhat backward in the use of electric power. Then a number of large central steam stations were put into operation. During the last few years the development of hydro-electric power has advanced to a surprising degree.

Water power has always been used to some extent, either for driving machinery direct or for electric generators. In 1921, according to figures announced at a meeting of the Power Board Engineers' Association at Wellington early in August, 1925, the total of hydro-electric plants in operation was 49,000 kw. In 1924 it had risen to 66,000 kw. and in 1925 to 90,000 kw. The total capital expenditure has amounted to £9,000,000 ($44,000,000) by the government, power boards and other local authorities. Most of the projects have been planned on a national basis.

The government has under construction or planning projects to cost £11,400,000 ($55,000,000) to provide 174,000 hp., with provision for extensions to generate an additional 85,000 hp. Some of these schemes have or will have long transmission lines, 50 miles and over. While probably not known to many American engineers, such projects as Arapuni, Coleridge, Hora Hora and Mangahao are large and modern hydro-electric plants that required considerable engineering skill. It has been stated that development of power in New Zealand has been too rapid of late, but when all is considered, it is admitted that the trend is in the right direction.







How Oil Comes to Market

SOME oil pipe line companies find that it is cheaper to use steam pumping engines in the oil pipe line stations when handling a high grade crude than to run oil engine driven pumps. In such cases coal is invariably used for fuel. The illustrations on this page are of a station in Illinois which pumps Illinois oil toward the Atlantic seaboards.

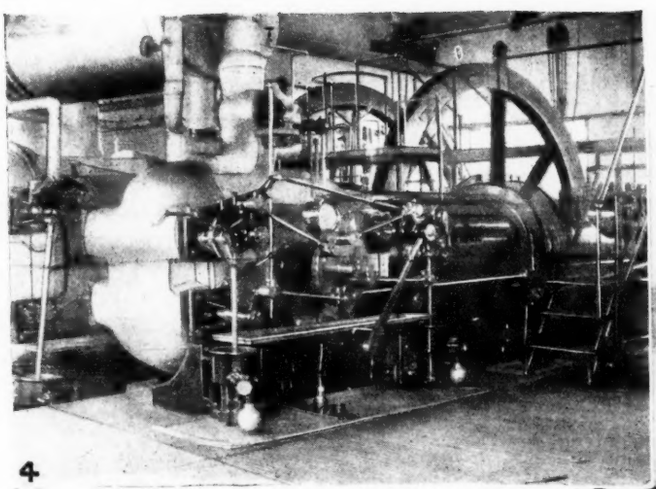
Fig. 1—A liberal stock of coal is kept on hand

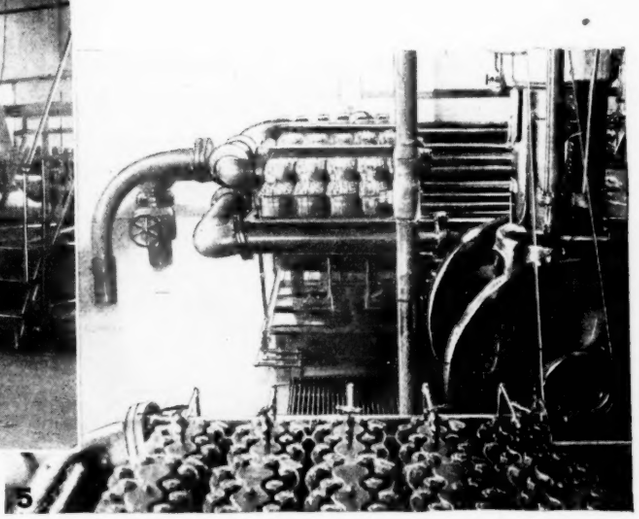
Fig. 2—This plant has 13 horizontal tubular boilers

Fig. 3—Even the stack is of modern design

Fig. 4—Two triple-compound steam engines are direct connected to the pump cylinders

Fig. 5—The oil pumps are sectionalized to reduce replacement costs





Specification of Grates for Boiler Furnaces

By V. E. Holyoke

THE object of this article is to furnish a general and simple guide for the specification of grates for boiler furnaces to meet various combinations of conditions that might exist in a hand-fired steam heating or power plant.

The accompanying table covers the kind and size of coal used, type of plant, pressure and service, the nature of the draft and the type of boiler furnace.

The purpose of a grate is twofold, namely, to support the fuel bed and to provide means for supplying oxygen for the combustion of the fuel.

In general bituminous coal is best served by shaking grates since agitation of the fuel bed assists in freer passage of air through the fuel. Anthracite can be handled best on dumping grates, since it burns better without agitation. Under certain conditions, however, a combination shaking and dumping grate will serve to good advantage under the smaller sizes of anthracite.

The size of coal determines the size of mesh to be used. When specifying the size of mesh mention should be made of the percentage of free air space in the grate, as this may vary with any one size of opening. The free air space for hard coal is limited to a maximum of about 30 per cent, while that for soft coal ranges from 25 to 50 per cent. Soft coal can be retained upon a grate with a wider opening because of the bridging action of this fuel.

Dumping Grates for Soft Coal

Many industrial plants use soft coal on shaking grates, but when these plants come within the limits of areas restricted to the use of hard coal, for smoke prevention, the chances are that dumping grates are used. Dumping grates are more successful in high-pressure plants where expert firemen and licensed engineers are employed who can give constant attention to the furnaces.

In smaller plants operating under low pressure, such as are found in apartment houses, small hotel and office buildings, employing less skilled labor, and in many instances having janitor service only, which is more or less intermittent in the boiler room, a combination shaking and dumping grate is often used with satisfactory results.

The grate area for the development of a definite boiler output must be larger for anthracite coal than for bituminous, since anthracite burns so much more slowly. A simple check on the grate area for nominal boiler ratings can be made with the use of the following table:

RELATION OF GRATE SURFACE TO BOILER HEATING SURFACE

For No. 1 Buckwheat	1 to 40 sq.ft.
For No. 2 Buckwheat	1 to 35 sq.ft.
For No. 3 Buckwheat	1 to 30 sq.ft.
For No. 4 Buckwheat	1 to 25 sq.ft.
For high-grade bituminous	1 to 55 sq.ft.
For medium-grade bituminous	1 to 50 sq.ft.
For low-grade bituminous	1 to 45 sq.ft.

The following specification is typical for a boiler plant generating low-pressure steam for heating, and burning No. 1 buckwheat coal under natural draft in possibly a firebox type of boiler furnace with grates designed for the particular service and furnished separately from the boiler.

Sample Specification

Grates: Furnish and install in each boiler a set of shaking and dumping grates with sectional removable tops having a ¼-in. checkered mesh with approximately 38 per cent free air space for burning No. 1 buckwheat coal under natural draft.

The grates are to fit the boiler with proper allowance for expansion and are to consist of all castings, forgings and fittings, and operating lever, inclusive of front bearer bar, constituting the grates complete.

The grates are to be arranged in two rows longitudinally with divided shaking and dumping movement front and rear.

The drilling of ashpit fronts shall be done by the boiler manufacturer in accordance with blueprints furnished by the grate manufacturer.

SPECIFICATION TABLE FOR GRATES FOR BOILER FURNACES

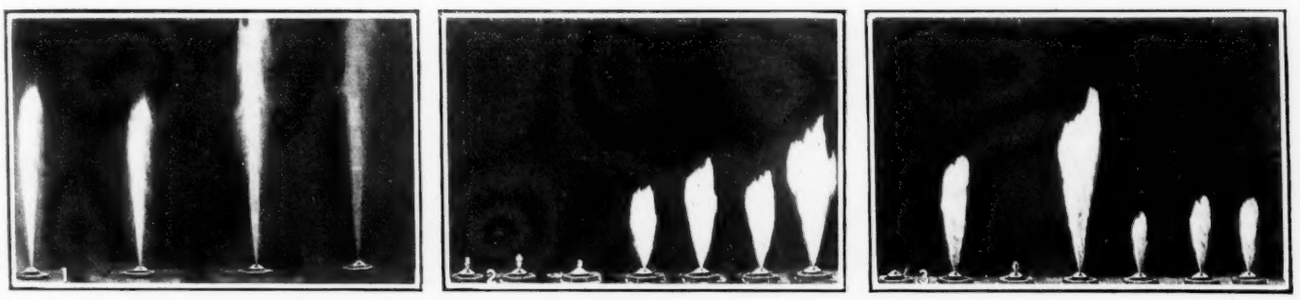
Kind of Coal	Service	Kind of Plant	Type of Grate	Size of Coal	Size of Mesh, Inches	Per Cent Free Air Space Approx.	Kind of Draft
Soft coal (Bituminous)	High Pressure	Industrial	Shaking	(Soft coal) run of mine	3/8	43	These grate meshes will work satisfactorily under natural draft. Forced draft may be used without change of grates where over rating of boiler is desired.
				slack	1/4	35	
		Heating	Shaking	(Soft coal) run of mine	3/8	43	
				slack	1/4	35	
	Low pressure	Heating	Shaking	(Soft coal) large brick	3/8	43	
				set boilers	1/4	35	
			Shaking and dumping	(Soft coal) fire-box type	3/8	41	
				of boiler	1/4	38	
Hard coal (Anthracite)	High pressure	Industrial	Dumping	No. 1 buckwheat	1/4	32	Natural
				No. 2 buckwheat	1/8	19	Forced
				No. 2 buckwheat	1/4	32	Strong natural
				No. 3 buckwheat	3/32	12	Forced
				Culm	1/16	7	Forced
		Heating	Dumping	No. 1 buckwheat	1/4	32	Natural
				No. 2 buckwheat	1/8	19	Forced
				No. 2 buckwheat	1/4	32	Strong natural
				No. 3 buckwheat	3/32	12	Forced
				Culm	1/16	7	Forced
			Shaking and dumping	Pea	1/4	44	Natural
				No. 1 buckwheat	1/4	38	Natural
				No. 2 buckwheat	3/32	29	Forced
				No. 2 buckwheat	1/4	38	Strong natural
	Low pressure	Heating	Shaking and dumping	Pea	1/4	44	Natural
				No. 1 buckwheat	1/4	38	Natural
				No. 2 buckwheat	3/32	29	Forced
				No. 2 buckwheat	1/4	38	Strong natural

Atomization Obtained in Fuel Nozzles Of Solid-Injection Oil Engines

By ROBERTSON MATTHEWS*

ONE of the first problems undertaken at Langley Field is the investigation of the high-speed oil engine was that of atomization. It was felt by all concerned in this experimental work that a study should be made of the characteristics of the sprays formed by the oil when ejected through a nozzle. The plan was to take moving pictures of the jet during the "building up" period and during its subsidence and dribbling, permitting the experimenters to determine the degree of atomization obtained during injection into the atmosphere and into compressed air.

Upon preparing to take these pictures, it was difficult to obtain sufficient illumination for the length of exposure permissible with such high velocity objects. Hence "still," or single pictures, were taken, using the same apparatus but concentrating all the illumination in one electric flash instead of distributing it over the period required by a succession of exposures. The flash was timed to catch the jet issuing from the nozzle, at a predetermined stage in the discharge.



Figs. 1 to 3—Photographs of oil-spraying into the atmosphere

Sets of these pictures appear in Figs. 1 to 3, kerosene being the oil used, discharging into the atmosphere through a 0.012-in. plain orifice. Pump pressures were 3,000, 5,000 and 9,000 lb. per sq.in. Although the jet with 5,000 lb. pump pressure, Fig. 2, is wider than when 3,000 lb. was used, as in Fig. 1, the 9,000-lb. jet in Fig. 3 does not show an increase in width. This may be due to misadjustment of the apparatus, for it had not been perfected sufficiently to insure positive action of all the parts. The theory of such abrupt discharge has not been completely developed, consequently photographs should not be trusted implicitly.

The general formation of the jet during the progress of injection lends itself well to photographic recording. However, the minuteness of the spray particles cannot be revealed by photography any better than by observing with the unaided eye. The jet, when finely divided, appears in the photograph as a cloud, and in order to determine photographically the degree of atomization, or the size of the oil particle, it would be necessary to isolate a thin slice of the jet, as in microscopic work. Comparison of jet forms is recordable, but for a study of fuel-particle size the photograph is not as instructive as is the observation of the spray floating in the atmosphere and the effect of attempts to ignite it at different distances from the orifice.

An enlargement of photographs of the jet from the same 0.012-in. nozzle using kerosene at 8,000 lb. pressure appears in Fig. 4. Except for the narrowness of the jet cone, the illustration gives the impression that the fuel was wholly atomized as from a whirling, or centrifugal, nozzle. On the contrary the jets retained a core of small diameter of sufficient density and velocity to draw blood when one's finger was inserted in the fluffy mass at the top.

The spherical top on the jet at the left in Fig. 4 is due not to a sudden diffusion of the atomized fuel, but was more likely caused by back splash or other influence from an opening in the chamber opposite the nozzle.

Photographs taken of jet action into compressed air of 300 lb. pressure show a slightly wider core, but the differences are not important. The degree of atomization resulting from impact of fuel upon dense air, although commonly supposed to be great, is not appreciable; at least experiments with 300 lb. air so indicate. The penetrating power of jets from plain orifices, when the stream is not restricted by a minute valve lift, is considerable. The illustrations, Fig. 2 especially, show that appreciable atomization does not occur at an early stage in the discharge, and the jets maintain their form until the oil particles are some distance from the orifice.

The dribbling portions of the jets are of equal interest, but photographs of the discharge at this stage are more difficult to obtain. Often the dribble appears as a slender broken thread or stream, frequently assuming a spiral shape.

In view of the controversy among engineers as to the action of oil injection in a hot-bulb engine, Fig. 5

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should be of interest. This shows the effect of kerosene issuing from a 0.012-in. orifice and striking a red-hot plate inclined 45 deg. to the jet axis. At *A* the oil was under 4,000 lb. pressure, and at *B* the pressure was 6,000 lb. per sq.in. The higher pressure did not appreciably change the jet form up to its contact with the plate, but after striking the plate the spray is less diffused than is the case with the lower pressure. No doubt this is for the reason that the greater velocity of the higher-pressure jet across the plate gave less time for vaporization. The plate was heated by an electric coil to show cherry red in the dark and its surface, while smooth, was not highly polished.

It is apparent that atomization alone is not the prime requisite in obtaining good combustion. As large an amount of vaporization as possible is desirable, and that combination of effects which will bring about the largest amount of vaporization, is the goal. Photographs and visual observation of jet formation are of less benefit in engine development than the determination of vaporization and combustion characteristics. The more perfect the atomization achieved, the less the value of photographic records of the history of the development of a spray injected into a chamber where no combustion occurs. The total interval of injection includes conditions more obscure and difficult to control than the build-up period of the jet. This interval can be determined readily by the simple, inexpensive method of taking spray patterns on the flywheel rim.

The apparatus used in these experiments consisted of a camera with lens manually covered and uncovered by a cam operated through a bell crank and having no part in the timing of the exposures, and a motor-driven camshaft with mechanism arranged to permit either one or several revolutions, much as in punch-press operation. The nozzle valve was held shut by heavy spring pressure and was operated automatically by the oil pressure after the cam relieved the valve of the spring load. A set of spark gaps with reflectors were situated around the nozzle, and while not giving direct light to the camera, illuminated the jet. A number of electric condensers for supplying the flashes at the spark gaps were used with a timing mechanism attached to the camshaft such that the condensers could be discharged at any instant in the progress of the jet formation. It will be observed that this equipment is somewhat costly. Hence where records of the jet are not required for file, much the same information can be obtained with an oscilloscope, which is a relatively cheap form of instrument.

Fig. 4—Enlargement of kerosene spray

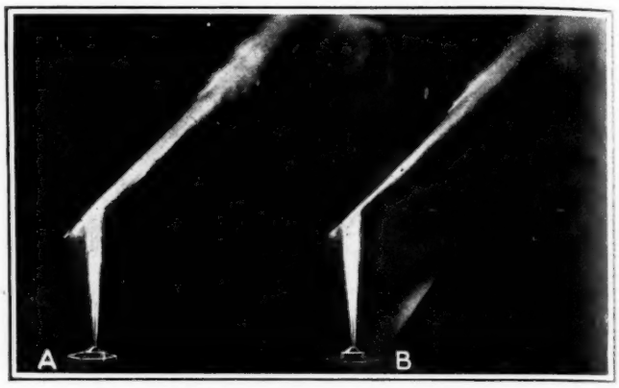


Fig. 5—Impingement of spray on hot surface

Photographs were not obtained of discharge from whirl or centrifugal nozzles. This type probably cannot be surpassed for fine atomization by any design that can endure rapid service and giving equally positive cutoff.

The true average coal consumption per kilowatt-hour for any period cannot be obtained by taking a simple average of the daily, weekly or monthly coal consumption per kilowatt-hour during that period. For example, suppose the total coal consumption for each of four successive weeks is 200,000 lb., 150,000 lb., 180,000 lb., and 220,000 lb., the corresponding outputs being 50,000 kw.-hr., 30,000 kw.-hr., 40,000 kw.-hr. and 60,000 kw.-hr. Then the coal consumption per kilowatt-hour will be 4 lb. for the first week, 5 lb. for the second, 4.5 lb. for the third and 3.66 for the fourth. The average of these four is 4.29 lb. Now the total coal consumed for the four-week period is 750,000 lb. and the corresponding output 180,000 kw.-hr., giving a true coal consumption per kilowatt-hour of 750,000 ÷ 180,000 = 4.16 lb.

Doubling the length of a beam cuts in half the load it can safely carry. One ton placed at the center of a beam stresses it as much as two tons uniformly distributed over the distance between the two supports. If a cantilever (overhanging) beam can carry a given load safely at the end, the same beam with two supports as far apart as the overhang of the cantilever beam can safely carry four times the load if placed at the center and eight times if uniformly spread over the distance between the supports.

On Being Kind to Boilers

Feed Water is the Diet—Watch It!

BY NORMAN LEE

IT MAY seem strange to say that so mechanical a thing as a boiler is very human. It resents poor treatment—particularly bad feeding—in much the same way as does the human body, being subject to acid stomach (corrosion), gastritis (foaming and priming) and gallstones (scale). Moreover, it is like some

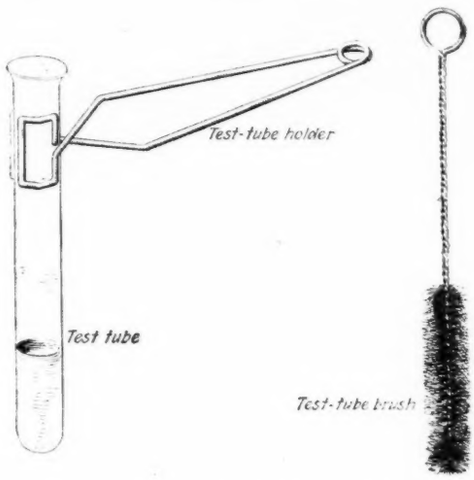


Fig. 1—Test tube, holder and brush

persons I know—who have a particular aversion to fat, not eating butter, hating cream, and preferring their salad dry—for a boiler will get quite "hot under the collar" if the slightest oil gets into its system. All these ailments are troublesome, especially gallstones, requiring as it does, a serious operation.

Just as a man of excellent physique may be reduced to an invalid by improper feeding, so may a boiler, but if well treated, it will be good for many years of work at high efficiency.

BOILER IS "HUMAN" IN ITS FONDNESS FOR SOFT WATER

The food for boilers is, naturally, water. Here again the boiler is human in its preference for "soft" over "hard" water.

Anyone who has ever washed in rain water, from roof or cistern in the country, will appreciate what "soft" water is, with its delightfully easy soaping characteristics—more especially if he has just come from the city and is accustomed to his daily shave with "tap juice" of non-lathering propensity. This very sensitiveness of water to soap is the basis of a test for determining just what sort of "dope" must be given the "baby" so that he may be contented and function properly.

Most of us have run across the word "precipitate." It is a long word for a very simple thing. In solving a cross-word puzzle, the other day, there was a four-letter word described as "precipitate in ice crystals"—twenty-four letters for four—which after a moment's reflection I found to be *snow*. As everyone knows what snow is and as it is truly a precipitate, I will frequently use it in place of the longer word.

Real snow is formed when freezing water vapor falls, sometimes as soft white flakes, sometimes as sleet or just slush. Much the same thing happens in boilers. The water fed to it is rain, and yet we find an accumulation or heavy layer of "snow" or scale every so often. Contrary to nature it is heat and evaporation, instead of cold, which causes this "snow" to form, or, to speak more technically, the salts held in solution at ordinary temperatures separate out under the combined influence of heat and concentration in the boiler.

EASIER TO SHOVEL SNOW THAN TO CHOP ICE

Just as in real life we would much prefer to shovel soft flaky snow or even sweep away slush rather than pick and hammer at hard incrusted sleet, so, in a boiler, the problem is to have the "snow" in the softer forms rather than as flint-like scale, so that it may be sluiced out or "blown off" and need not be chipped away. It is

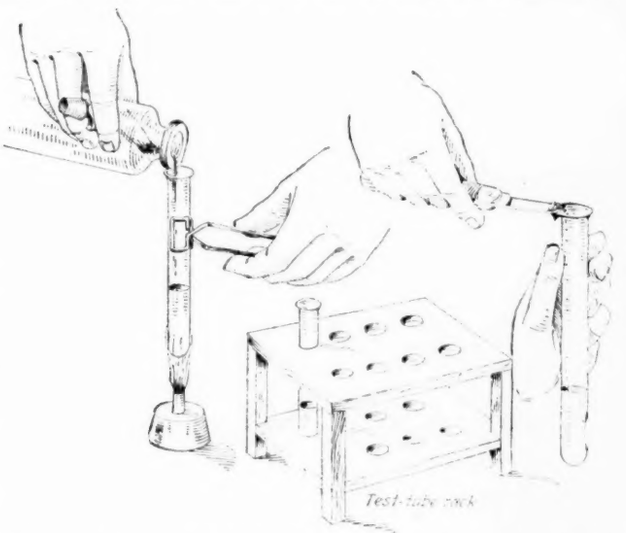


Fig. 2—Left: Method of handling reagent bottle and stopper. Right: Adding ammonia crystals in magnesia test

almost needless to say that this chipping is a disagreeable and expensive process and not at all good for the boiler and that, if it could be avoided, the boiler man's life would be far more agreeable.

As the boiler has plenty to do in evaporating water without being required to act as a chemical precipitation tank, it would be preferable to eliminate the "snow" before the water ever gets into it, having a tank or some arrangement apart, where this may be done. While this is far more elegant and ideal, it is not always convenient, so that oftentimes the water is treated with some medicine as it enters the boiler, causing the "snow" to become "slush," easily gotten rid of.

Just why do we want to get rid of scale? Because it forms an insulating covering on the inside of the boiler, which prevents the heat of the coal from getting into the water where we want it, and its presence translates itself into a higher coal bill, together with overheated or buckled plates which damage the boiler. Moreover, as heat is one of the deciding factors in causing this "snow," it deposits rapidly the instant the water becomes hot and clogs the feed pipes sometimes completely.

Oil is also an efficient heat insulator; even a thin film will act like a blanket and shoot the coal bill up, attended with buckled plates, bagged tubes and other complications. None should ever be allowed to enter the feed water. Acidity in the water causes rust or corrosion, pits, grooves, etc., affecting the boiler almost as sulphuric acid would affect the stomach.

The More Common Impurities

Practically all waters contain some salts in solution when cold, which will precipitate out in the boiler to form scale. By far the most common are: Limestone, chalk or marble (calcium carbonate); gypsum or plaster of paris (calcium sulphate); magnesia (magnesium carbonate); epsom salts (magnesium sulphate). Of these, the first is held in solution by virtue of the carbon-dioxide (or carbonic-acid gas) contained in the water. That water easily takes up this gas, is proved by the facility with which it may be "charged" to make soda water by circulating through it the gas under pressure from a cylinder. As carbon dioxide is a constituent of the air to the extent of one part in four thousand, any water in contact with air will absorb some of it. Now when water is heated some of this gas is driven off, rendering the salts less soluble, so that they precipitate out to form "snow." The trick will be turned if we can find some substance to add to the water which will drive off or absorb the carbon dioxide and thus precipitate the "snow" without being harmful in itself. Fortunately, there are such substances. With some magnesium salts, such as magnesium chloride, the effect is somewhat different, as at high temperatures they decompose and produce harmful reactions, principally corrosion.

The first thing to do then, is to determine what injurious salts there may be present, and whether the water is acid or alkaline. We will need a few test tubes and materials, as called for on the following list:

One half-pint bottle of soap solution.
One 2-oz. bottle of lime water.
One 2-oz. bottle of chloride of barium.
One 2-oz. bottle of chloride of ammonium.
One 2-oz. bottle of hydrochloric acid.
One 2-oz. bottle of nitric acid.
One 2-oz. bottle of carbonate of ammonia (crystals).
One 1-oz. bottle of phosphate of soda (crystals).
Slips of blue litmus paper.
Slips of red litmus paper.
One small spirit lamp.
One test-tube brush (Fig. 1).
One test-tube holder (Fig. 1).
Six test tubes (Fig. 1).
One 4-oz. flat-bottom, clear-glass bottle.
One test-tube rack (Fig. 2).

These can be supplied by any chemist. The soap solution can be prepared by putting some fine scrapings of white curd soap into a bottle and pouring alcohol upon it. Cork the bottle and set it on one side for a few days, shaking it every so often until the soap is all dissolved. Then add a little soap, and if you find you have too much, add a little alcohol, so as just to dissolve it.

Lime water is prepared by slaking a small lump of freshly burned lime with half its weight of water (distilled) in a vegetable dish. Then take the slaked lime and put it in a bottle with some cold distilled water, shaking it occasionally. Let the undissolved portion subside, draw off most of the clear liquid and keep it tightly stoppered in a clean bottle.

It will no doubt be easier to give a druggist this entire list and ask him to make up the soap solution and lime water as above, at the time he supplies the other materials.

How to Find Out What's in the Water

We are now ready to go ahead. Take any clean bottle, fill it with the water you desire to test, and proceed as follows:

To see Whether the Water Is Soft or Hard—Take a clean test tube and pour into it about three-quarters of an inch of the soap solution; then add three or four drops only of the water. If the solution becomes milky or curdy, the water is appreciably hard.

To See Whether the Water Is Alkaline or Acid—Into a test tube half filled with water dip a strip of red litmus paper; if it does not turn blue, the water is not alkaline. Now dip a strip of blue litmus paper into the water; if it does not turn red, the water is not acid.

To See if There Is Chalk—(with carbon dioxide)—To about three-quarters of an inch of the water in a test tube add just as much lime water; if chalk is present, the water will become milky ("snow"), and on adding a little hydrochloric acid the water will become clear again.

Test for Gypsum—To 1½ in. of the water in a test tube add a little chloride of barium; if a white precipitate is formed and it will not dissolve when you add a little nitric acid, gypsum is present.

Test for Magnesia—Fill a test tube about one-fourth or one-third full of water; hold it with the tube holder, and bring it to a boil over the spirit lamp; then add the point of a knife full of carbonate of ammonia crystals and a very little phosphate of soda. If magnesium is present, it will form a white precipitate, but as it may not do so at once, it is best to set it one side for a few minutes in the test-tube rack.

General Instructions

Great cleanliness is essential. When you pour from a bottle, lift out the cork with the second and third fingers, turning the hand over, and held it thus while manipulating as shown on the left in Fig. 2. Remember to rinse the test tube out thoroughly before using, with the water you are about to test. After finishing one test, and before proceeding to another, again rinse it out with the water, using the brush if necessary. Use fresh clean water each time for these rinsings. The object is of course, to prevent the presence of any salts or foreign matter except such salts as are naturally present in the water to be tested.

All these tests have been what the chemist calls "qualitative"; they tell *what* is in the boiler but not *how much*. Intelligent feed-water treatment must be based on a "quantitative" analysis of the feed water—that is an analysis showing the quantity of each salt present in the water. Such an analysis is necessarily carried out by chemical specialists.

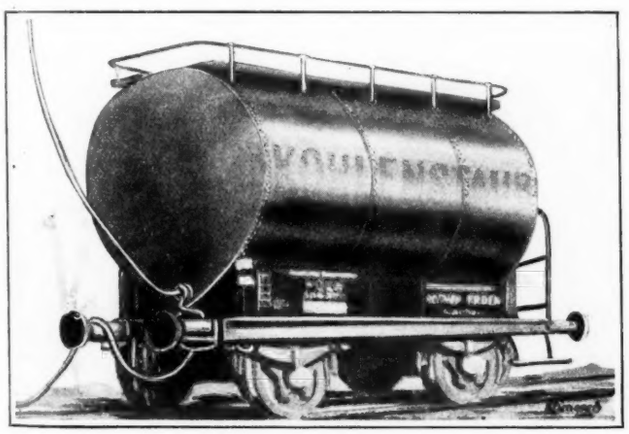
The actual treatment of the water is generally accomplished by the use of lime and soda ash in suitable amounts. "Suitable amounts" is a short phrase requiring a long explanation. Nothing of the sort will be attempted here. When it comes to actual treatment of the water, the wisest thing to do is throw one's self on the mercy of the manufacturer of the softening equipment used or on some other bona fide specialist. It is just as essential that the specialist have long practical experience in this field as that he be well equipped with general chemical knowledge.

Water refuses to stay simple. It has a most annoying habit of picking up stuff on its travels, much as a small boy accumulates marbles, tops, coins and a little bit of everything else. This makes it impossible to lay down simple hard-and-fast rules for water treatment. Just as is the case in medicine, there seems to be at least one exception to every rule.

Finally, do not drug your boiler with nostrums of unknown composition. At the worst such treatment may be positively injurious. At the best you pay a fancy price for simple ingredients.

Tank Car for Powdered Fuel

The Germans are already advertising tank cars for the transportation of powdered fuel. Reproduced from an advertisement in a recent issue of *V.D.I.*, the accompanying cut shows a car designed for transporting any sort of powdered fuel. Note the V-shaped bottom designed to facilitate removal of the powdered fuel by compressed air. The claim is made that an air pressure



German tank car for pulverized fuel

of 30 lb. will deliver the fuel to a point over 3,000 ft. from the car. Suction may also be used for the same purpose.

Sixty-Two Years of Service

This is the record of the "old timer" shown in the accompanying illustration, a vertical, marine type, condensing engine employing a slide valve with riding cutoff. With a cylinder 36x36-in., a speed of 70 r.p.m. and steam pressure of 100 lb., the engine was rated at 350 horsepower.

Installed in 1863 in the Union Elevator at 16th St. and the River, Chicago, by the Schenectady Iron Works (long since absorbed by the American Locomotive Works), the old engine has been in daily service supplying all the power needed by an elevator of 1,750,000 bushels capacity. The unit was belted up to the shaft floor at the top of the structure, and the various conveyors were belted down from the main jackshaft.

Steam was supplied by two vertical tubular boilers whose pressure had been cut down recently to 70 lb. The cylinder exhausted into the rectangular receiver crowning the four vertical columns of the engine frame. Through three of these columns the exhaust steam was

Old-time vertical engine that has given 62 years of service

carried to the hollow bedplate which discharged to a jet condenser. Nozzles projecting up into the bases of these columns sprayed into the downcoming steam, making it possible with the jet condenser previously mentioned to obtain a vacuum of 25 to 26 in. ordinarily and on light load 2 in. more.

A recent fire totally destroying the elevator, ended the useful life of the engine. Of sturdy construction it was still in good physical condition and would have continued to function for many years to come. According to D. Cullman, the engineer in charge since 1903, little had been required for maintenance. About 1915 the cylinder had been rebored and at the same time the old jackscrew packing on the piston had been replaced by snap rings. No figures are available on economy except that the coal requirements to operate the house, depending upon grain receipts and shipments, ranged from one to three tons of coal in an eight-hour day.

Coal that costs the Ford Company approximately $5 a ton delivered at the River Rouge Plant, is converted into from $12 to $13.50 worth of coke and byproducts by the byproducts recovery plant which is now in operation.

The Wing Rotor

WHILE the large-scale generation of power by the wind is not generally considered commercially feasible at the present time, the windmill is not entirely an outcast in the field of power production. For hundreds of years it has filled a real need in small isolated units used for pumping water, grinding grain, etc. Undoubtedly, the most important application of the wind has been to the driving of sailing ships, which

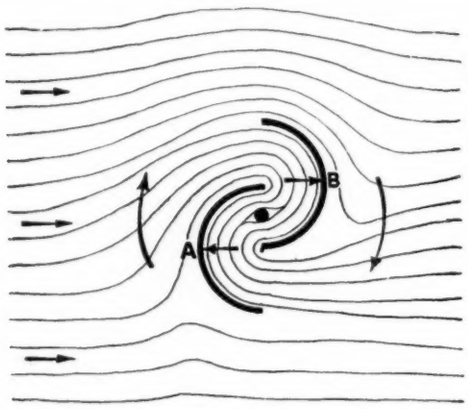


Fig. 1—Horizontal cross-section of wing rotor. Note that A is propelled by wind spilling from B

have had an immense influence on the development of civilization.

It is only recently that serious attempts have been made to design windmills scientifically, although they are obviously as susceptible to such treatment as waterwheels. Most windmills erected have been of such a trifling character as not to interest scientifically trained designers.

A new development of great interest as a novelty and giving considerable promise of replacing the older type

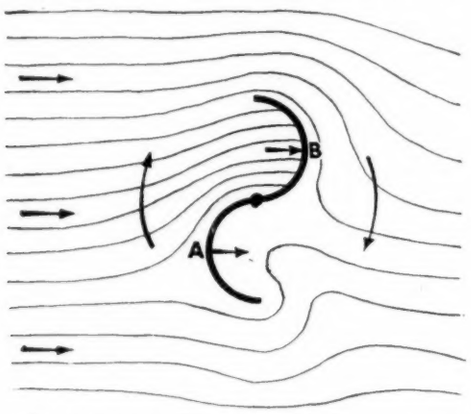


Fig. 2—This arrangement gave less power and speed than that of Fig. 1

of mill for small-scale uses, is the so-called "Wing Rotor," recently invented by Engineer-Captain Sigurd J. Savonius, of Helsingfors, Finland. This might be described as a sort of cross between the ordinary windmill and the Flettner "rotor" described in the Dec. 30, 1924, issue of *Power*. For those who have not read the article referred to, it will suffice to say that the Flettner rotor is a smooth vertical cylinder rotated by auxiliary power. When a breeze strikes such a cylinder, it exerts a force at right angles to the direction of the wind. Such towers or rotors mounted on a ship and driven by small engines act as the equivalent of large sails. The wind, of course, merely pushes on the cylinder without appreciably assisting in its rotation.

Imagine a Flettner rotor sawed in two along a plane passing through the axis, the two halves being displaced along this plane as shown in Fig. 1. This evidently makes of the rotor a two-bladed windmill. Captain Savonious experimented with various positions of the blades, but found that the arrangement shown, with the edge of each blade at the center of the other, gives the greatest capacity and speed. When the two blades are joined at their edges to form a letter S, as shown in Fig. 2, the forward push on blade *B* is partly counterbalanced by a backward push on *A*. With the arrange-

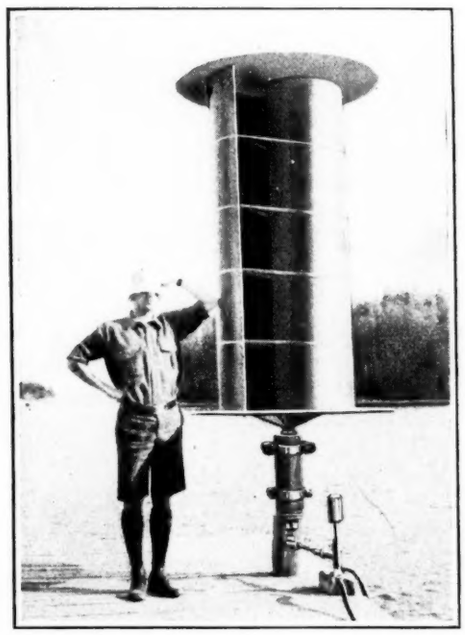


Fig. 3—Wing rotor arranged for pumping water

ment used, on the other hand, both blades are pushed in the direction of rotation, the forward push on *A* being accomplished by the air spilled off of *B*.

Fig. 3 shows a test rotor rigged up for pumping water. Unfortunately, the results obtained have not been reported in terms of energy delivered at the rotor shaft. The original report of the inventor merely gives the strokes per minute and the liters of water pumped per hour at various wind speeds. The net pumping head is not given. The results, therefore, are not reproduced here, as they have little value for scientific comparison. Engineers would be particularly interested in curves showing the relation of wind velocity, rotor velocity and power delivery for rotors of various dimensions.

While definite information seems to be lacking on many points, the claim is made that the wing rotor will develop considerably more power per square foot of projected area than a windmill of typical design. Having a vertical axis and being of simpler construction than the ordinary windmill, the wing rotor should be cheaper to construct and erect.

Two rotors of this sort with provisions for "furling" have been applied to the propulsion of a small boat.

Mechanical Eyelids

THE recent development in England of a binocular stroboscope as compact and portable as a pair of field glasses is in line with the modern tendency to make scientific instruments conveniently available for general use. The stroboscope is, in effect, a pair of mechanical eyelids capable of being winked at any desired rate. An imaginary being equipped by nature with such a pair of eyelids could see many things invisible to his less-specialized fellows. By winking at the proper rate, he could bring a spinning flywheel to "rest," each spoke and scratch standing out as sharply as in a still photograph. Of more importance would be his ability to study vibration directly. With the aid of a mark or two on the circumference the observer could easily see just where and how much a shaft was running high or low.

Nature has not provided man with such eyelids—perhaps he is more comfortable without them—but she has given him enough brains to design and construct his own, just as in the telegraph, telephone, microscope and radio he has in effect added to his own body. Whenever a laboratory instrument has been reduced to convenient portable form, its field of usefulness has quickly broadened. The same will undoubtedly happen with the stroboscope.

Detroit Smoke Ordinance

ACCORDING to news reports the Common Council of the City of Detroit has passed the smoke ordinance that has been under discussion there for several months. The ordinance goes into effect late in October, and at that time the Mayor is to appoint a chief and several assistants who will comprise the Smoke Inspection Bureau of the city. It is unnecessary to emphasize the importance of this matter. Detroit, in common with many of our northern cities, has been getting increasingly dirty with the growing difficulty of securing anthracite and high-grade bituminous coal for the small consumer.

The ordinance that has been prepared seems to have been well considered and, so far as can be judged, is well drawn. On the other hand, experience in many places demonstrates that even more important than the ordinance and the form of organization is the personality of the man selected to stand at the head of the work. The City of Detroit is to be congratulated on the first step well taken, and it is earnestly hoped that in selecting men for appointment to this important bureau of the city government, a happy selection will be made. Political considerations must be set aside, and the men selected must be of high-grade engineering caliber with wide experience in combustion control, with familiarity with boiler settings and operation and with sufficient force of personality to enable them to advise the ordinary fireman concerning the performance of his daily task. The appointees must further be able to "sell" the idea of smoke prevention to owners of buildings and small industrial establishments. Such activities call for men of outstanding ability, as engineers and as diplomats. Knowledge and tact are alike indispensable.

We shall all watch the progress of this movement in Detroit and hope that it may be a repetition of the excellent work done elsewhere by forthstanding men in this field.

Water Power Not a Magic Wand of Industry

THERE seems to be some mystic charm in power that grips the human imagination and leads it into all kinds of flights of fancy. This is true not only of those who know nothing about the problem, but not infrequently those who should know better allow themselves to give utterance to public statements that not only violate all sound laws of engineering and economics, but also ignore the dictates of reason and every-day common sense. It cannot be disputed that power is one of the most potent factors in our modern civilization, nevertheless, it represents a small part of the cost of production in most commodities.

Last year the gross income of the electric power companies in this country was over one and one-quarter billion dollars. But this sum represents only about one per cent of the value of the country's business for the same period. If the value of the power produced in industrial plants is assumed to equal that produced in central stations, the cost of power as produced by stationary power-generating equipment is only two per cent of the value of the business in the country. This value checks with the average cost of power in manufactured products, which is about two per cent. Therefore, if the manufacturers of the country were given their power free, they could only be expected to reduce their costs two per cent. Notwithstanding this condition, good intentioned and otherwise, persons continue to rave about a few hundred thousand horsepower of more or less doubtful water power creating billions of new wealth, giving employment to millions of men, giving the farmers cheap fertilizer, revolutionizing the cost of manufacturing and so on indefinitely. Muscle Shoals has furnished the inspiration for many of these literary flights of fancy during the last few years, and millions of dollars have been invested in real estate around the Shoals to the tune of such high-sounding statements.

At present development of the tide power at Passamaquoddy Bay in the Bay of Fundy adds more fuel to the literary fire. This project is reported to be capable of developing one-half million horsepower at a cost of one hundred million dollars, or two hundred

dollars per horsepower, which, although not unreasonably high, is about four times the cost of making some of the large water power in this country. Yet a noted editorial writer said in one of New York's leading newspapers that "this project will make Maine one of the greatest industrial states in the Union and add tens of billions of dollars to the State's wealth." Maine on her rivers has about five hundred thousand horsepower of underdeveloped water power, and also a law against exporting this power, but it is not attracting industries other than those that go there for other economic reasons, such as raw materials and labor. If Passamaquoddy is developed it is possible that the power will be utilized outside that state, as the export restriction has been lifted in this case.

Pennsylvania, which has twenty-five per cent less potential water power than Maine, not including the Passamaquoddy project, and has developed only about fifty per cent of this, has become the second industrial state in this country, with Maine ranking in about the twenty-eighth place. The ratio of the value of manufactured products in these two states is about sixteen to one. Such facts as these should make some of those who have been carried away with the cheap water power idea see that low-priced power may not be such an influence in attracting industry as it has been pictured, and probably other economic factors have as great or even greater influence. Our water powers are a great national asset and should be utilized wherever possible, but they are not a magic wand that creates industries out of hot air.

Smoke at Home

THE present threatened shortage of hard coal, coming at the opening of the heating season, affords to readers of *Power* an opportunity for civic service.

Many readers might properly qualify as combustion experts. About us on every hand are friends and neighbors who have to operate small heating plants, often unskillfully, so that the domestic heating furnace is one of the worst offenders in the production of smoke in practically all of our Northern cities. The probability that many persons heretofore accustomed to using anthracite will be forced this winter to use various substitutes therefore increases the problem of smoke reduction.

Unsolicited advice is usually unappreciated and unheeded, but in a question so largely affected with public interest, it behooves us who are able to advise others to see to it that our advice is solicited and heeded.

Good work has been done in some cities by way of organizing public meetings at which experienced men have explained how to burn soft coal, coke, etc., in the heating of houses, without the production of excessive smoke. Newspaper publicity should be developed to the utmost. Brief articles in the women's pages of current dailies have proved of great value, and it was found that the editors were often glad to receive such material. In some cases capable men have been willing to visit the homes of inquirers and advise them as to the operation of their heating equipment.

All such efforts, given freely and often grossly undervalued by the recipients of advice and assistance, are none the less steps in the right direction. We frequently bemoan the fact that engineers are not sufficiently prominent in matters of civic welfare. Here is a splendid opportunity.

The Absorption Refrigerating System Deserves More

EVEN the daily press is filled with columns of facts and near facts on how to save in power costs. If the reduction of such costs be desirable, why do not the builders and users of refrigerating machinery give more attention to wider use of the absorption refrigerating system?

The Carré absorption system was the first workable method of manufacturing ice and is still being installed, but taken as a whole, the ice and cold-storage industries depend upon compression machines. Probably one of the reasons for this choice is that many absorption machines proved unreliable in service. Much of the trouble has been due to the inexperience of the operating engineer, whose fund of information has not been increased to any extent by contact with factory troublemen who, if they really understood the system, kept the knowledge to themselves. In addition it must be conceded that much inferior apparatus was installed. Both of these objectionable features can be eliminated by proper design and instruction of the operating force.

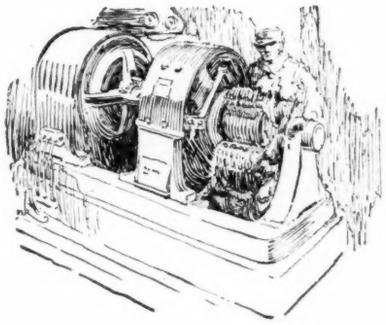
The absorption system is particularly attractive in plants where exhaust steam is available. While atmospheric pressure can be made to supply heat to the absorption generator, to obtain satisfactory capacity the steam should be somewhat higher. This might place too much of a back pressure on engines already overloaded, but usually the gain due to the absorption system will be greater than the loss from a long cutoff in the engine. It is possible by a proper exhaust valve arrangement to supply steam at release pressure to the absorption machine and still keep the engine's back pressure at atmospheric or, better still, at a condenser pressure.

The advent of small- and medium-capacity bleeder-type turbines and bleeder engines permits an absorption system to be operated at a high efficiency. Its over-all economy under such conditions is so far superior to the compression system that it will not be surprising to find industrial plants receiving the Carré system.

It seems that with kind treatment the working life of an engine may easily exceed that of a man. As related on page 571, only destruction by fire stopped a vertical steam engine that had served a grain elevator from Civil War days, sixty-two years in all. It appears that well-made steam engines, particularly the old-time ploddingly reliable slow-speed engines "mothered" by engineers of the same type, are practically immune from wearing out. This may not be an unmixed blessing. There are doubtless many old engines still operating because the owner cannot bear to junk a machine that is still in good shape. Sentiment is all right in its place, but such matters should be decided by balancing capital charges on new equipment against the savings obtainable.

The President's Muscle Shoals Commission assembled again last week in Washington with the expressed intention, according to its chairman, of remaining in session until a definite solution has been arrived at. It is to be hoped that the other members are in agreement with the chairman on this point at least.

Practical Ideas from Practical Men



WITH a view to stimulating engineers into the habit of recording for the benefit of brother engineers, unusual occurrences, how these were met and other practical expedients adopted in the operation of their plants, Power has decided to award two cash prizes each month during 1925. One of $25 for the best and another of $15 for the second best practical letter on plant operation or practical kinks received during the month. This is in addition to payment for the contribution at space rates. The winners for September will be announced next month.

Power is pleased to announce the awards of the judges for the first and second prize contributions received during August for this department in accordance with the terms of the contest as stated above.

The first prize of $25 goes to Charles R. Underhill, of Waterbury, Conn., for his article on "Improving the Power Factor," in the Sept. 22 issue.

The second prize of $15 goes to A. F. Graves, of Pittsfield, Mass., for his article on "Calibrating Feed-Water Meters in the Small Power Plant," in the Oct. 6 issue.

The judges were: (Chairman) Willis Lawrence, mechanical engineer, Interborough Rapid Transit Co., New York City; Norman N. King, chief engineer, Singer Bldg., New York City, and D. L. Fagnan, formerly refrigerating engineer, and more recently associated with the Smoot Engineering Corp., New York City.

Rewinding Burned-out Field Coils With the Old Wire

While I was at the plant of the New England Fish Co., Noyes Island, Alaska, the field coils burned out on the direct-current generator, which was driven by a gas engine. This generator furnished light and power for the cannery. The operator had been having trouble to keep the generator up to voltage and, when the rheostat was cut out of the field circuit, had resorted to speeding up the engine. This procedure came to an end in a few days, as the field coils were slowly burned out.

I was called in to find the cause of the trouble. Upon starting the generator it required increased tension on the brushes to make it build its voltage. Checking the speed showed it to be 2,200 r.p.m., which was far above normal. After the machine had run about one hour under load, I went over it for heating, and found the armature and commutator normally warm from friction. While pressing on the field coils, I pushed a hole into one, finding it completely burned out. On examining the balance of the field coils, two more were found completely burned out and a third in fair condition. How to get the machine back into service without seriously delaying operation was the question. If new coils or wires were to be obtained, they would have to come from Seattle, which would delay operation of the plant for about 15 days.

This time, being the middle of the fishing season, meant a big loss to the company. After pondering over the situation half the night, I thought of a way of winding the coils, by using white store string as an insulator along with strips of wrapping paper and shellac. A form, to wind the coils on, was made from cardboard and a block of wood, with an iron rod through the center. One end of the rod was bent to form a crank for turning the form, and the other end was supported on a salmon box when the wire was being wound on the form. The string was used to insulate between turns as they were wound on, and wrapping paper formed the insulation between layers. The wire from the old coils and the string were wound both in hand, using the string as a spacer between the turns. After each layer was wound on, it was given a good coat of shellac, then a layer of paper was placed over the wire. This process was followed until all the wire on the old coil had been wound on the new one.

After two days of winding the job was completed ready to reassemble the machine. When the generator was put back into service, its speed was reduced to normal, 1,700 r.p.m., and it developed normal voltage with an ample margin. H. M. SMITH.

Noyes Island, Alaska.

"Calling in the Expert"

In every power plant, no matter how clever the engineer in charge may be, there comes a time when outside advice and help would be most useful, but through fear that they may lose their positions from incompetence, or a false valuation of their knowledge, many engineers prefer to rely upon themselves and struggle through somehow. And why this should be so is difficult to understand unless we go back some fifty years, when the engineer had to depend upon himself, as specialists and experts simply did not exist; but today conditions are upon an entirely different footing. The careful study of the advertising pages of the engineering magazines should convince the most optimistic engineer that new methods and ideas are cropping up continually and different ways of doing things are increasing accordingly, which fact increases the engineer's chances of doing the wrong thing.

Our medical doctors, in times of doubt, do not hesitate to suggest obtaining the advice of the specialist, or our legal adviser recommends taking the opinion of counsel before giving the advice sought for, and we all accept these methods without question as to incom-

petence, and why engineering problems should not be treated in a similar manner, particularly where the expenditure of large sums is involved, is I think due to the engineers themselves and the aforementioned fears of being considered incompetent.

Some thirty years ago the writer with other practical engineers had the privilege of listening to an informal lecture by the late Lord Kelvin. We were all practical men anxious for knowledge, nevertheless many of us, to use a popular phrase, "thought we knew something," but none of us required larger hats when the lecturer finished. To illustrate the importance of avoiding "guessing at things," we were asked "how long it would take to walk across the room and ring a bell?" Various times were at once given, all far from being correct. The lecturer then walked quietly across the room, rang the bell and said, "Gentlemen, the exact time is five seconds." My own estimate was 35 seconds. This little test, one of many received from this great man, impressed one and all that it is easy to take things for granted. Since that time I have met many engineers, and I am convinced that it is the greatest and cleverest that are most anxious to seek the advice of others, and no doubt this seeking and discussing of ideas is the secret of their greatness.

We also find today that all our principal plant-equipment manufacturers carry upon their staff experts anxious to give us free advice at all times. Some I know are likely to look upon this with suspicion, thinking that whatever is offered will be "biased information," but I have consulted many of these experts and have yet to find one who has deliberately tried to mislead me or press upon me something unsuitable.

There is to be found the world over "engineering monuments" upon which should be inscribed, "In memory of an engineer who consulted nobody." But the present-day engineer need have no fear of adding to the number if he utilizes every opportunity of consulting the experts and thus add much to his knowledge and prestige as an engineer. F. P. TERRY.

Belfast, Ireland.

Parallel Operation of Central Station and Industrial Plant Proved Economical

It is not often that we find an industrial power plant designed with as much care as a large central station and operated with the same close scrutiny, in order to secure power at the lowest unit cost, but the writer was employed at one time in a large textile plant in which this was accomplished.

The power requirements of the mill were about 3,000 kw. an hour for a period of nine hours a day and approximately 2,000 kw. an hour of the demand was furnished by three waterwheels located in the same room as the engine and connected to alternators. These alternators were operated in parallel with the engine-driven unit and also with the public-service plant in a near-by city.

On the same river above our plant were a number of paper mills that ran 24 hours a day, and hence the rate of water flow was nearly the same throughout the 24 hours. But we had no use for power between 4:30 p.m. and 6:45 a.m., so the plan of parallel operation with the power company was worked out. As soon as the mill was shut down at 4:30, the tie line switch was closed, which permitted us to send 2,000 kw.-hr. into the lines of the power company, thereby reducing the load on its steam-driven units.

For eight months in the year this amount of power was supplied and about 1,000 kw.-hr. for two months, while during the remaining period of two months there was not enough water to justify the operation of the hydro-electric plant. As no process steam was required, the engine was operated condensing in summer, but the demand for low-pressure steam for heating permitted non-condensing operation in the winter, as the steam flow was around 25,000 lb. per hour and no exhaust was wasted to the atmosphere. This unit was also connected to the tie line and considerable power furnished in winter only by the following practice: At 4:30 a.m. each working day, steam had to be turned into the heating system in order to heat the mill to 70 deg. by 6:45 a.m., and to supply this steam a load of 800 kw. was carried on the engine, the current going into the tie line till the mill started. After 9 a.m. the demand for steam in the heating system dropped off and the load on the engine reduced in proportion, and an equivalent amount of current was taken from the lines of the power company.

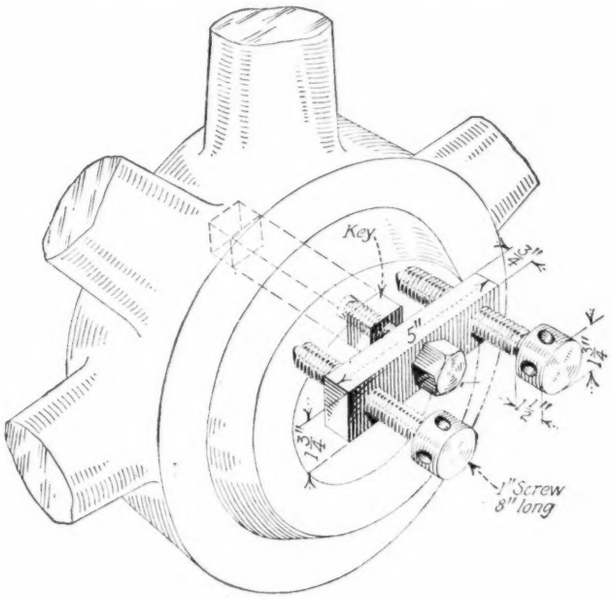
The exchange of current was effected at the rate of 2 kw.-hr. being given to the power company in exchange for each kilowatt-hour taken from its lines. But the mill supplied much more than twice as much current as received, so the excess current was paid for by the power company at ½c. a kw.-hr. The amount of current delivered to the power company's lines by the waterwheels was 2,000 kw. for fourteen hours a day, for six days a week and an average of nine months a year, and the steam unit supplied about 800 kw. for three hours a day for six months a year. The mill drew from the power company about 200 kw. an hour for nine hours a day the year round, as it did not have sufficient capacity to generate all the power required. In round figures the total power sent out by the mill power plant was 7,000,000 kw.-hr. a year and that received was about 572,000 kw.-hr., which was repaid at the rate of 2 to 1, making the net output 5,856,000 kw.-hr. At ½c. per kw.-hr. the income accruing to the mill was $29,280 a year, which proved the undertaking to be highly profitable to both parties as the power company's plant was overloaded and the peak load came on at night after the mill was shut down.

This contract was made at the time of installing new waterwheels in the mill at a cost of over $100,000, but these wheels would have been purchased anyway as the old units, which had been belted to the main shaft, were over 25 years old and no longer serviceable. So this plan did not involve any higher capital charges, and the only added expense is the salaries of two extra operators and the maintenance charges. Of course it is doubtful if the power company would have made this contract if its own plant had been of ample capacity; it would either have demanded a lower rate for the current it received or, as is frequently the case, would not have listened to the idea of exchange of current. Many power companies will make no connection with an industrial plant except for the purpose of selling power, owing to the fact that their load factor is already low and apparently this plan of operation makes it still lower, but the idea can be profitably applied in a great many cases, since it reduces both the operating costs and investment charges of both parties.

Chicopee, Mass. J. A. MADSEN.

Tool for Removing Keys

It frequently happens that engineers are confronted with the problem of removing keys that have been driven practically flush with the hub and the end of the shaft. The illustration, which is self-explanatory, shows



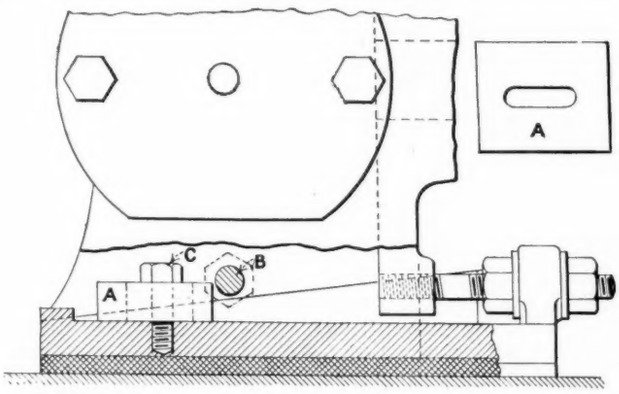
Key is drilled and tapped for maximum size bolt

a tool we have made for doing this work. The dimensions are given on the sketch and one size of puller will take care of several sizes of keys. D. W. LEWIS.

Fessenden, N. D.

Preventing Shoe from Leaving Crosshead When Take-up Bolt Breaks

For some time past we have had trouble with the take-up bolt on the lower crosshead shoe of our Corliss engine breaking and allowing the shoe to leave the crosshead entirely. When this would happen, the piston rod would be sprung and the shoe broken before the



Block fastened to shoe prevents damage to engine when take-up bolt breaks

engine could be stopped. After this had occurred a couple of times, we decided to provide some means of holding the shoe in place temporarily after the bolt broke, until the engine could be shut down.

We concluded that the simplest way to do this was to fasten the iron block *A* to the shoe and let it rest against the through clamping bolt *B*. The block was made to fit between the tapered sides of the crosshead and was clamped in place with the ¾-in. bolt *C*. A slot was provided in the center of the block as shown in the detail to permit adjustment of the shoe. When adjustment is necessary, the capscrew is slackened and the shoe taken up. Then the block is pushed against the clamp bolt *B* and capscrew *C* is tightened.

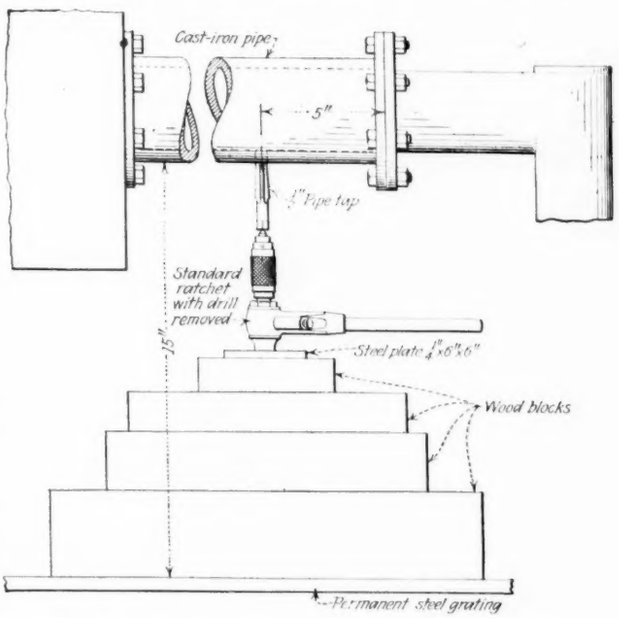
Although there may be a more practical method of doing this, the one shown here has proved satisfactory.

Wabash, Ind. I. N. WILLIAMS.

Starting a Tap With the Aid of a Ratchet

In order to provide a means for sampling pulverized coal at the feeder box, it recently became necessary to drill and tap for a ½-in. nipple on the under side of a cast-iron pipe which served as a casing for a screw conveyor.

Drilling was easily accomplished by means of a



How ratchet was used in starting pipe tap

standard ratchet and drill supported by blocks from the floor.

Difficulty was not encountered until we tried to start the tap in the hole, when it was discovered to be almost impossible to do so owing to the fact that the hole had been purposely left small to insure a full thread so that the joint would be tight without having the nipple extend into the pipe, where it would foul the revolving worm screw.

Finally, we hit upon the idea of utilizing the ratchet for starting the tap in the same manner as is often employed when tapping a piece held in a lathe chuck, where the tailstock center is used to line up and start the tap.

We removed the drill from the ratchet and built up to the required distance with blocks of wood topped with a small piece of steel plate. Then, as the illustration would indicate, we simply followed up the tap with the feeding screw of the ratchet.

Brooklyn, N. Y. G. C. LICENCE.

Comments from Readers

Specification for Horizontal Return-Tubular Boilers

There has been considerable discussion in *Power* from time to time on the subject of engineers being required to know the formulas used in boiler construction before they are issued a license. The following is a part of a typical specification, taken from a boiler-maker's catalog, for a 72-in. by 19-ft. 6-in. horizontal return-tubular boiler to be built to conform to the boiler rules of the Commonwealth of Massachusetts and the A.S.M.E. Code in every detail, for a working pressure of 125 lb. per square inch.

GENERAL DIMENSIONS OF BOILER

Diameter of shell measured outside of smallest course	72 in.
Length over all	19 ft. 6 in.
Number of courses	3
Distance between heads, outside to outside	17 ft. 11½ in.
Thickness of shell	7/16 in.
Thickness of heads	½ in.
Thickness of butt straps	7/16 in.
Number of tubes	96
Diameter of tubes	3½ in.
Length of tubes	18 ft. 0 in.

Shell plates and butt straps to be up to gage on edges and to be made of homogeneous openhearth fire-box steel, having a tensile strength of not less than 55,000 lb. per sq.in. nor more than 63,000 lb. per sq.in., with a yield point not less than one-half of the tensile strength and an elongation of at least 26 per cent in a length of 8 in.

The chemical test to show not over 0.03 per cent phosphorus, 0.04 per cent of sulphur, and from 0.30 to 0.50 per cent of manganese.

The longitudinal joints to be of the butt-joint type, quadruple-riveted, designed to comply with the rules formulated by the Massachusetts Board of Boiler Rules and to have an efficiency at its weakest part of 94 per cent of the solid plate.

Longitudinal joints to come well above the fire line of the boiler and to break joints in the several courses.

The girth seams to be of the lap-joint type, single-riveted, and to have an efficiency of at least 35 per cent that of the longitudinal seams.

All rivet holes to be drilled; that is, the holes to be punched ¼ in. small and the plates, after being rolled, to be bolted together with covering straps and heads in position, and all the holes drilled out to size, thus insuring perfectly fair holes, so that no drifting will be required to bring the holes in line. After drilling the holes, the plates are to be taken apart and the burrs removed from the edges of the holes. All riveting to be done with a hydraulic riveting machine wherever practicable, pressure to be kept on each rivet until it has taken its shrinkage to insure tight joints.

Each head above the tubes to be braced by sixteen 1¼-in. diameter diagonal weldless steel braces of the solid crowfoot type, or flat steel braces of equal area, arranged to stay the entire surface properly. Each head below the tubes to be braced by two through weldless steel braces 1½ in. in diameter, upset at the front end to 1¾ in. diameter, the back end to be upset and drop-forged in the form of an eye and secured by means of a pin 1⅞ in. in diameter to two 6x3½x⅜-in. angle irons securely riveted to the head. The angle irons to be spooled off from the head 3 in. so that the additional thickness of the metal in the angles will not be subjected to the action of the fire.

A boiler built to the foregoing specifications could not be installed in Massachusetts. Although it might be installed in other states, I believe that it would give the engineer considerable trouble in operating it. Any engineer that cannot see the catch in these specifications by careful reading should get out his textbooks and brush up a little. BURTON W. WHEELER.

Rockland, Mass.

Compulsory Systems of Weights and Measures

I read with a great deal of interest the Foreword in Aug. 18 issue on "Compulsory Systems of Weights and Measures." It is unfortunate that the advocates of the so-called English system of units are letting well enough alone, which is certain to bring defeat. The metric advocates are active and they may attain success temporarily.

It should be comparatively easy to make the English units into a regular binary system. For example, leaving the inch as it is, make the octic foot eight inches long. Also, with the pound as it is, divide it into eight octic ounces. Eliminate the present yard and substitute four octic feet. Only by the gradual change of our units of weights and measures to a regular system of eighths can the decimal arithmetic be displaced.

The problems of the best system of arithmetic, money, weights and measures are for practical psychologists, and I believe that they have wholly overlooked their opportunities. Anyone particularly interested in this subject would find it well worth while to read the able and scholarly paper on "Octonary Numeration," by A. M. Taylor, published in the proceedings of the American Philosophical Society for October, 1887, which may be found in the Columbia University library.

The base sixteen is too large, as it requires five new figures and a much larger multiplication table than we now have. Octic arithmetic eliminates the figures 8 and 9 and reduces the size of the multiplication table.

We have advanced a long way unsuspectingly toward octics by dividing per cents into thirty-seconds, in stock and bond transactions.

The thousandth scale of our micrometer was a step in the wrong direction. The scale should have continued the binary divisions by dividing sixty-fourths into sixteenths. In the octic notation this is 0.0004.

Oak Park, Ill. E. M. TINGLEY.

Gas Temperatures Throughout Boilers Burning Pulverized Coal

The relation between temperatures of gases and heating surfaces passed over, has been the subject of much discussion, and at the present time has gained paramount importance with the use of pulverized fuel and furnaces constructed for increased boiler capacities with large area of water-heating surfaces exposed to the fire.

Superheater performance in a like manner is greatly affected by these new developments that decrease the initial temperature of the gases at the boiler tubes.

It has been general practice to design boiler furnaces based on the softening point of firebrick, maintaining during maximum continuous operation a temperature around 2,500 deg. F.

The new developments make it imperative to design furnaces according to the actual initial temperature of gases, which must be below the melting point of the ash to prevent the erosion of brickwork and accumulation of ash in the boiler tubes. This will necessitate an increased amount of direct heating surface that will greatly reduce the temperatures throughout the first pass of the boiler and affect the superheat.

In comparison to stoker firing it has been noticed that the degree of superheat is lower when pulverized fuel is burned. This, however, cannot be attributed to the additional direct heating surface if the gases pass over 50 per cent or more of the heating surface before reaching the superheater.

The lower temperature of superheat is probably due to the small amount of excess air required. Taking 12 per cent CO_2 as a basis, the stack temperature will diminish 1 to 3 per cent and the superheat will decrease 3 to 8 per cent for each 1 per cent increase in CO_2.

The furnace temperatures increase rapidly with the increase of CO_2 and would be enormously high if it were not for the boiler surface directly exposed to the fire. The regulation of this direct heating surface and the percentage of excess air in proportion to the fuel burned controls the furnace temperatures, the calculation of which is made comparatively simple by the use of the chart, Fig. 1.

The initial temperatures determined, the superheater designer employs a formula of his own selection for the amount of heat imparted by convection from the heated gases to the boiler, when determining the location of the integral superheater within the setting.

Numerous attempts have been made to correlate the experimental data with the theoretical deductions similar to the chart, Fig. 2, which shows the application of

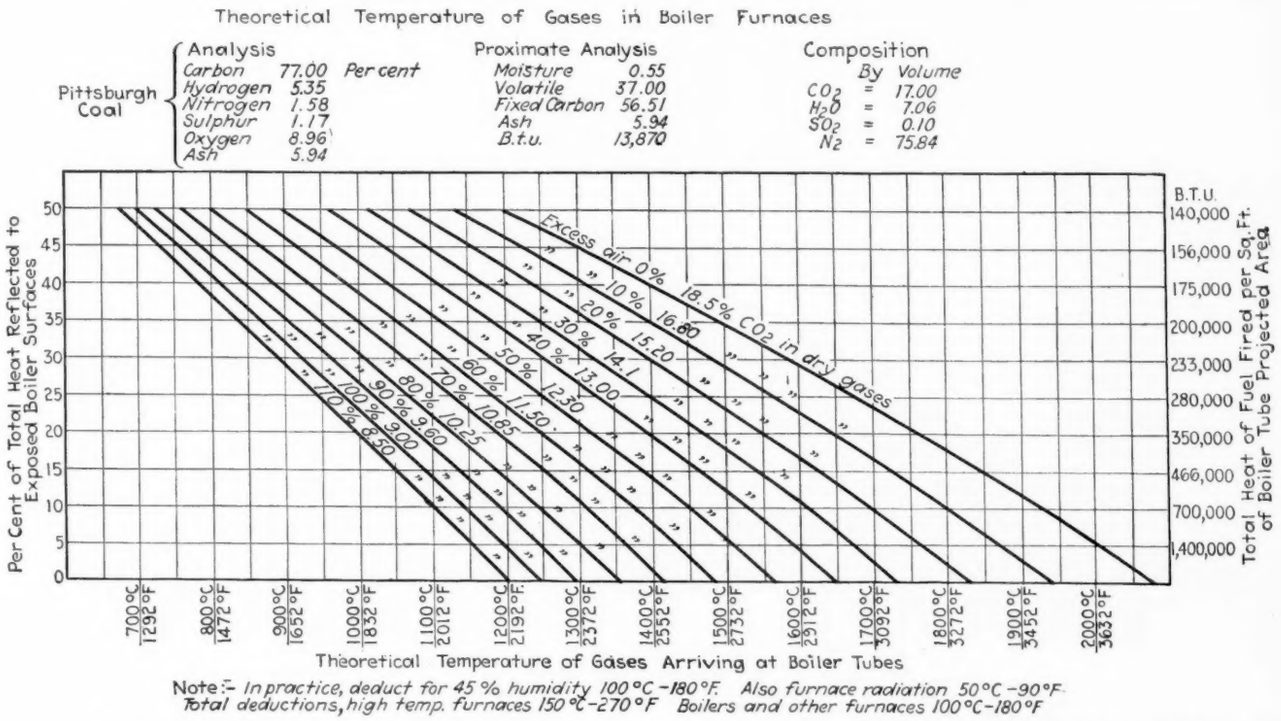


Fig. 1—Theoretical temperature of gases in boiler furnaces at different ratings and percentages of CO_2

Fry's formula, a certain superheater manufacturer's data and actual results obtained at the Mines de Bruay, France, burning pulverized fuel at the rate of 1,433 lb. per hour (11,300 B.t.u. per lb.) at 14 per cent CO_2 in a 2,080-sq.ft. Buttner boiler having a superheating surface of 54 sq.ft. As originally installed, the furnace volume was 880 cu.ft. with 65 sq.ft. of boiler-heating surface (projected area) directly exposed to the fire. The chart, Fig. 2, shows the initial temperature as 2,300 deg. F. and the reduction throughout the boiler to an exit temperature of 545 deg. F.

The boiler furnace was then changed and the volume increased to 1,140 cu.ft. with 95 sq.ft. of surface directly exposed to the fire. With the same amount of fuel and air being burned as in the first case, the initial temperature became 1,940 deg. F. and diminished throughout the boiler to the same final temperature, 545 deg. F.

This trial has been of considerable interest, as it shows that: (a) When burning the same amount of fuel and air in a boiler furnace, the exit temperature of the gases remains the same in each case and is not affected by the proportion of heating surface directly exposed to

the fire; (b) superheat is not affected if the superheater is placed after 50 per cent of the boiler surface; (c) an additional amount of the direct boiler-heating surface did not increase the total heat absorption.

A careful examination of the curve will indicate that by increasing the amount of direct heating surface the heat absorption of the boiler is more uniformly distributed and the local strains in any particular part are

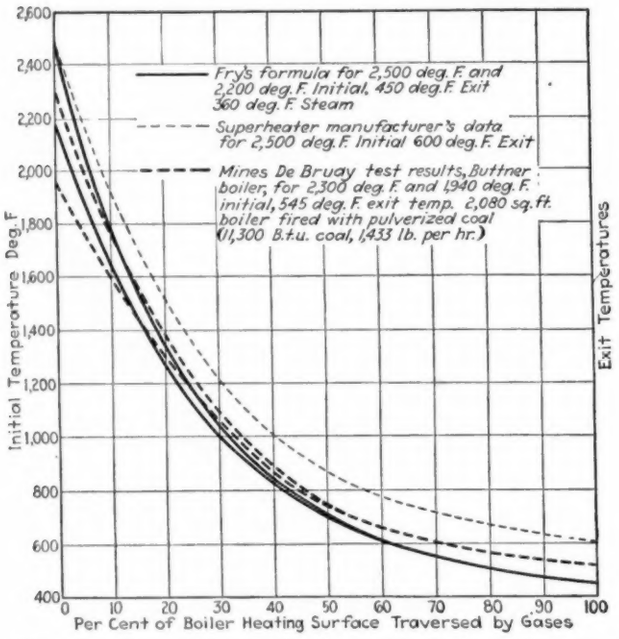


Fig. 2—Comparison of initial and exit temperatures determined by formula and actual tests

decreased, which obviates the question whether pulverized fuel can be used in old boilers now in operation.

New York City. J. GOULD COUTANT,
Furnace Engineering Co.

Units of Evaporation and Capacity

The Foreword in the June 2 issue pointing out the need for two names to designate a practical unit of heat absorption and a more rational unit of power as applied to boiler performance, is more than interesting. It is a just cry for a very necessary unit of measure.

It seems to me that a practical unit would be the "kilotherm," as suggested in the symposium in the July 28 issue. This term is applicable not only to evaporation in a boiler, but to any heating operation involving the evolution of or work done by 1,000 therms. With reference to the unit of capacity "kilotherm-hour" would be the correct designation for this unit. These designations line up with "kilowatt" and "kilowatt-hour" and indicate similar things. We would then have the corresponding designations: Kw. = kilowatt, kw.-hr. = kilowatt-hour, kt. = kilotherm, kt.-hr. = kilotherm-hour, which are distinctive and susceptible of easy handling without error by all.

Springfield, Ohio. WILLIAM JACOBI.

The Foreword in the June 2 issue and the discussion in the July 28 issue deal with a most important subject and one that receives too little attention. In reference to steam production and boiler output standards, several points still await decision, both in England and the United States. It is, of course, highly important (I would say vitally important) that the decision be identical in both countries.

As the unit of output is dependent on the unit of production, a settlement of the latter is the first necessity. Personally, I do not see why we should drop the unit so long used, "the pound of water evaporated as from and at 212 deg. F." I do not here refer to the phrase (which is cumbrous and bad) but to the thing. Consider how the actual output of a boiler is measured. We begin with an actual quantity of water evaporated, under other conditions. This is multiplied by an "evaporation factor" derived from a steam table, and the product is in what we may, for the present, call "Ev. U." (evaporation units). As the actual output is necessarily measured as a quantity of water to begin with, we are not freed from the steam table and its discrepancies, even though the 1,000 B.t.u. basis is adopted. The proposed change of about 3 per cent in the steam-production unit which has been long in use seems to me to give no advantage to compensate the decided inconvenience it will produce.

I strongly recommend the following solution:

(a) The unit of steam production is the transfer of heat equal to the conversion of 1 lb. of water at 212 deg. F. into steam at the same temperature and at 14.7 lb. absolute per sq.in. pressure.

(b) The unit defined in (a) shall be termed an "Evaporation Unit" (Ev. U.) or such other name of one word as may be agreed upon.

(c) The unit of boiler output shall be the production of 1 Ev. U. per hour.

As to names, the discussion in the July 28 issue discloses an interesting divergence of opinion. Personally, I think "evaporation unit" is quite satisfactory for the production unit, and "evaporation unit per hour" for the output unit. If, however, special names are desired, much the best plan seems, not to invent two ugly words by mutilating others, but to adopt the plan of the International Electrical Units and use the names to commemorate pioneers in the use of steam. The production unit might be called a "Regnault" (he being the first to produce by observation a valuable steam table, though his figures have naturally been somewhat modified later), or we might call the unit a "Hero," commemorating the earliest known steam generator. I think it is best not to give a name to the unit of output, as this seems to tend to produce confusion as between quantity and rate.

Bolton, England. G. A. ROSSETTI.

Overpressure in the Condenser

In an article on careless operation of refrigerating plants in *Power*, Sept. 22, Roland Tullis stated that the condenser pressure ran up to 300 lb. As far as I have observed, no plant is installed without a safety valve to care for such overpressure. It would be interesting to hear why the plant discussed was not so equipped.

In plants using large inclosed compressors, safety valves are put on the crankcase to prevent overpressure in the frame, as it is possible, owing to leakage, etc., for a high pressure to crack the crankcase.

While local rulings often care for safety valves, a national code is needed on this important point.

St. Louis, Mo. C. F. KLUGMANN.

Questions and Answers

Conducted by

Franklin Van Winkle

Crumbling of Firebrick Used in Furnace Repairs

In making repairs to our boiler furnace with firebrick left over after the boilers were set, the repaired sections are much shorter-lived than the original furnace linings, apparently due to crumbling of the firebrick. What may be the cause of the trouble? *W. S.*

The crumbling probably is due to using the boiler furnaces without allowing sufficient time for the repaired section to become thoroughly dried out after the repairs are made; and much longer time would be required for that purpose if the firebrick have not been stored in a dry place.

Boiler-Tube Heating Surface

Should the heating surface credited to tubes of a return-tubular boiler be computed on the basis of the internal or external surface of the tubes? *B. N.*

Boiler-tube sizes are quoted according to their external diameters and, for greater convenience, commercial computations of tube heating surface usually are based on the external diameters of the tubes. However, this method is inaccurate for return-tubular and other fire-tube boilers, as the true heating surface is the side exposed to the heated gases and therefore calculations of actual boiler-tube heating surface of fire-tube boilers should be based on the inside diameter, and the tube heating surface of water-tube boilers should be based on the outside diameter of the tubes.

Relative Quantity of Feed Water Evaporated at Different Pressures

With feed water at the temperature of 210 deg. F. what is the relative amount of water that must be evaporated for the same boiler capacity, when generating steam at 15 lb. gage as compared with generation of steam at 100 lb. gage? *H. W. B.*

As may be found from tables of properties of steam, the total heat above the temperature of 32 deg. F. contained by one pound (weight) of dry saturated steam at the pressure of 15 lb. gage, or 15 + 15 = 30 lb. per sq.in. absolute, is 1,163.9 B.t.u. Hence with feed water at the temperature of 210 deg. F. each pound of feed water evaporated into dry saturated steam at the pressure of 15 lb. gage must receive from the boiler 1,163.9 — (210 — 32) = 985.9 B.t.u.

The steam tables also show that when evaporation is at the pressure of 100 lb. gage, or 100 + 15 = 115 lb. per sq.in. absolute, the total heat contained by a pound of the steam is 1,188.8 B.t.u., and in that case, with feed water at the temperature of 210 deg. F., each pound of feed water evaporated into dry saturated steam must receive 1,188.8 — (210 — 32) = 1,010.8 B.t.u. Therefore when the feed water in each instance has a temperature of 210 deg. F., the same boiler capacity is developed for evaporation of $\frac{985.9}{1,010.8}$, or 97.5 per cent as much feed water into steam at 100 lb. gage as would be evaporated into steam at 15 lb. gage.

Perfect Vacuum Not Obtainable with Piston Pump

Why cannot a perfect vacuum be obtained with a piston pump? *M. F.*

The piston and valves may be perfectly tight, but a perfect vacuum cannot be formed because at the beginning of a suction stroke of the piston there will be some air or vapor in the cylinder clearance spaces at atmospheric pressure or whatever pressure the pump discharges against. Air and vapor expand indefinitely with increase of volume, and when the suction valves open, this clearance-space air, combines with the air in the suction chamber, and during the suction stroke the whole volume of air which is in communication with the suction side of the piston, expands by an amount equal to the piston displacement.

Effects of Voltage Variation on Tungsten Lamps

What is the effect of voltage variation on a tungsten lamp? For example, if on one lamp the voltage is 5 per cent low and on another of the same type it is 5 per cent high, what will be the variation in the life and candlepower of the lamp? *F. A. A.*

With a 5 per cent decrease in volts at the lamp terminals, the watts input will be decreased about 8 per cent, but the candlepower will decrease about 17 per cent and the normal life of the lamp will be increased over 100 per cent. It will be seen that although the life of the lamp has increased over 100 per cent, the efficiency has decreased 17 per cent. In the case of a 100-watt lamp that has a normal life of 2,000 hours at rated voltage, it will consume 200 kw.-hr., which at 10c. per kw.-hr., will cost $20. The lamp will cost about 50c., or 2.5 per cent of the power that it consumes, therefore, increasing the life of the lamp is of vastly less importance than maintaining a high efficiency.

An increase of 5 per cent in voltage will increase the wattage consumption of the lamp 8 per cent and the candlepower 19 per cent, but the life of the lamp will be reduced to less than 50 per cent. Although doubling the cost of lamps might not be a serious item to obtain more light in some cases, there are other factors that enter into the problem such as blacking of the bulb and excess illumination, that would make it undesirable to operate the lamp at excess voltage. If a lighting system is properly designed, installed and maintained, the best service will be obtained from lamps by operating them at rated voltage.

Measuring for New Piston Rod

Will you please outline a correct method to get the length of a piston rod, either keyed or screwed-end type, supposing the old rod was so bent or broken that you could not get the correct measurements from it? *H. H.*

Shim or adjust the connecting-rod brasses to obtain the same length of rod, center of crankpin to center of crosshead pin, as when the engine was turned out by the builder.

After removing the cylinder head, piston and old piston rod, place the crank on the crank-end dead center and make a mark on the crosshead and a corresponding mark on the guide to indicate the crank end of the stroke; then place the crank on the head-end dead center and make another mark on the guide to correspond with the mark previously made on the crosshead to indicate the head end of the stroke.

With the old piston rod removed from the piston, replace the piston in the cylinder, pressed hard against the crank-end head, and with a straight-edge laid across the end face or flange for receiving the cylinder head, mark on a gage rod the shortest distance from a point near the center of the piston to the straight-edge held in any position across the end face of the cylinder.

Then move the piston to the extreme head end of the cylinder and push it back by replacing the cylinder head; remove the head and, as before, mark on the gage rod the distance from the piston to the head end of the cylinder. Deducting the length of stroke from the distance between the marks made on the gage and bisecting that difference will give the piston-travel clearance that is obtainable in each end of the cylinder.

Now place the piston in the crank end of the cylinder the first gaged distance from the end of the cylinder, less the piston-travel clearance for the crank end. The piston then will be in proper position for the crank end of its stroke and, with the crosshead placed at the crank end of its stroke, the distance from the crosshead hub to the piston hub will be the length for fitting up the piston rod, measured from crosshead to piston, with due allowance for screwed or keyed ends. For obtaining this distance, provide two wooden rods, each about three-fourths the required distance hub to hub. Pass one rod through the stuffing box and with one rod sliding lengthwise over the other, make a mark across both rods where they lap, when the extreme ends are in contact between points whose distance apart is to be obtained. The distance then should be transferred to a single rod whose length, end to end, is the correct length of piston rod from crosshead to piston.

Efficiency of Butt and Double-Strap Joint, Double-Riveted

What would be the efficiency of a butt and double-strap joint, double-riveted, where the tensile strength of plate is 55,000 lb., thickness of main plates $\frac{3}{8}$ in., thickness of butt straps $\frac{5}{16}$ in., pitch of rivets in the outer row 4¼ in., and diameter of rivet holes $\frac{3}{4}$ in., with rivets filling the holes? *J. T.*

The efficiency of the joint would be the least strength of a unit of pitch P, indicated in the figure, divided by the tensile strength of solid plate of the same width.

If the tensile strength of the plate is 55,000 lb. per sq.in. of cross-section and the thickness of plate is $\frac{3}{8}$ in. = 0.375 in., then

(1) The strength of solid plate per unit of pitch P = 4¼ in., would be

$$4.25 \times 0.375 \times 55{,}000 = 87{,}656 \text{ lb.}$$

Having thickness of butt straps $\frac{5}{16}$ in. = 0.3125 in., diameter of rivets after driving $\frac{3}{4}$ = 0.75 in., giving cross-section area of rivets = 0.75 × 0.75 × 0.7854 = 0.4418 sq.in.; and allowing the strength of a rivet in single shear = 44,000 lb. per sq.in. of cross-section, strength in double shear = 88,000 lb. per sq.in. of cross-section of the rivet, and crushing strength of material = 95,000 lb. per sq.in., then the strength of the joint per unit of pitch P would be the least value obtained from the following considerations:

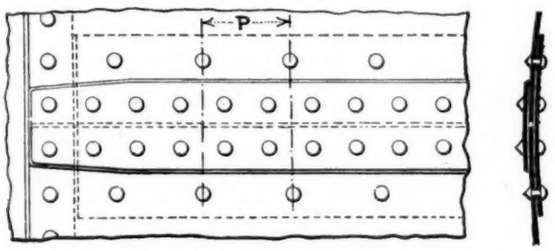
(2) Strength of plate between rivet holes in the outer rows =

$$(4.25 - 0.75)0.375 \times 55{,}000 = 72{,}187 \text{ lb.}$$

(3) Shearing strength of two rivets in double shear, plus the shearing strength of one rivet in single shear =

$$2 \times 88{,}000 \times 0.4418 + 1 \times 44{,}000 \times 0.4418 = 97{,}196 \text{ lb.}$$

(4) Strength of plate between rivet holes in the



Butt and double-strap joint, double-riveted

second row, plus the shearing strength of one rivet in single shear in the outer row =

$$[4.25 - (2 \times 0.75)]0.375 \times 55{,}000 + 1 \times 44{,}000 \times 0.4418 = 76{,}158 \text{ lb.}$$

(5) Strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row =

$$[4.25 - (2 \times 0.75)]0.375 \times 55{,}000 + 0.75 \times 0.3125 \times 95{,}000 = 78{,}984 \text{ lb.}$$

(6) Crushing strength of plate in front of two rivets, plus the crushing strength of butt strap in front of one rivet =

$$2 \times 0.75 \times 0.375 \times 95{,}000 + 1 \times 0.75 \times 0.3125 \times 95{,}000 = 75{,}703 \text{ lb.}$$

(7) Crushing strength of plate in front of two rivets, plus the shearing strength of one rivet in single shear =

$$2 \times 0.75 \times 0.375 \times 95{,}000 + 1 \times 0.4418 \times 44{,}000 = 72{,}877 \text{ lb.}$$

The least strength per unit of pitch P would be obtained from consideration (2), namely, 72,187 lb., and the efficiency of the joint would be result (2) divided by result (1), namely, 72,187 ÷ 87,656 = 0.823, or 82.3 per cent.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communication, and for the inquiries to receive attention.—Editor.]

A new slant on things observed in and out of the power plant

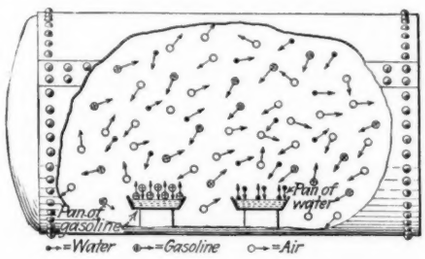
What Happens and Why?

How Gases and Vapors Match Up

A DRY gas is the exception in nature. Where there is air or other gas, there is generally water vapor as well. If dry air or any other dry gas is passed over water, it quickly becomes moist—that is, it becomes mixed with water vapor. These being the observed facts, it is the most natural thing in the world that practically all engineers as well as laymen should look upon air as having a sort of affinity for water—a tendency to soak it up as a sponge soaks up water.

Yet such a point of view is probably erroneous; it certainly tends to mislead those who hold it in the solution of practical engineering problems.

The real fact of the case seems to be, not that water vapor has an affinity for air or gas, but that it has a tendency



The quantity of water vapor or gasoline vapor present is not affected by presence of air or the other vapor

to rush into any space not occupied by a solid or liquid. Practically all such spaces with which we are familiar in daily life contain air or other gases, so it is easy enough to get the idea that the vapor is pursuing the air, when in reality it is only rushing into the voids which constitute almost 100 per cent of any space "filled" with gas at ordinary pressures. Whether the water vapor is after the air or merely the space is quickly settled by experiment. If a little water is admitted to an air-tight space from which the air has been evacuated, it will be found that the same weight of water will evaporate as if the container were originally "full" of dry air at atmospheric or any other reasonable pressure.

All this has been explained more fully in the article, "Can Air Carry Moisture," in the Sept. 29 issue.

What happens, in brief, is this. Molecules are always leaping from the surface of a liquid to fly about as vapor molecules in the space above. The more molecules of vapor there are per cubic foot of space above the liquid, the more will be absorbed. If accumulation is allowed to continue—that is, if the vessel is closed—a state must eventually be reached where as many molecules dive back into the liquid each second as leave it. At this point evaporation appears to cease, since the actual evaporation is exactly balanced by condensation.

Assuming for the moment that no air or other gas is present, for any given temperature the saturated vapor will have a definite weight per cubic foot (called the vapor density) and will produce a definite pressure (called the vapor pressure). For water these can be taken directly from the steam tables.

PROPERTIES OF SATURATED VAPOR, AND OF "SATURATED AIR" AT ATMOSPHERIC PRESSURE

Temp., Deg. F.	Vapor Alone — Density, Lb. per Cu.Ft.	Vapor Alone — Press., Lb. per Sq.In.	"Saturated Air" at Atmospheric Press. Lb. Water per Lb. Dry Air	"Saturated Air" at Atmospheric Press. Lb. Water per Lb. Mixture
32	0.00030	0.089	0.0038	0.0038
40	0.00041	0.122	0.0052	0.0052
50	0.00059	0.178	0.0076	0.0075
60	0.00083	0.256	0.0110	0.0109
70	0.00115	0.363	0.0158	0.0156
80	0.00157	0.505	0.0223	0.0218
90	0.00213	0.696	0.0311	0.0301
100	0.00285	0.946	0.0431	0.0413
110	0.00377	1.27	0.0593	0.0560
120	0.00492	1.69	0.0813	0.0751
130	0.00637	2.22	0.112	0.100
140	0.00814	2.89	0.153	0.133
150	0.0103	3.71	0.212	0.175
160	0.0130	4.74	0.299	0.230
170	0.0161	5.99	0.432	0.302
180	0.0199	7.51	0.658	0.397
190	0.0244	9.34	1.09	0.524
200	0.0298	11.52	2.29	0.696
212	0.0373	14.70	Infinity	1.000

Now if air or some other gas is present in the container, it will in no way interfere with the molecules leaving the water or with those diving back. Nor can the air molecules (in appreciable amount) dive into the water. Thus evaporation will go on just as if the air were not there until vapor has accumulated to the density shown in the second column of the table, for the given temperature. This density of vapor will likewise produce the vapor pressure shown in the third column.

Of course a gage attached to the container will indicate a pressure higher than this by the amount of the air pressure. Thus if the (air tight) tank orginally contained dry air at atmospheric pressure, and if the water and container were kept at a temperature of 200 deg. F., the final pressure would be 11.52 + 14.7 = 26.22 lb. per sq.in. absolute.

Suppose the container (still at 200 deg.) had a small leak—a pinhole. The total pressure could then not rise above that of the atmosphere. In that case as the total pressure started to rise above 14.7 lb. absolute, some of the air and vapor would be pushed out through the hole. The air thus passing out would be lost for good, but the vapor would be replenished by new evaporation. When a final state of equilibrium was reached, the space would be saturated with water vapor with a density of 0.0298 lb. per cu.ft. and a pressure of 11.52 lb. per sq.in. Since the total pressure of 14.7 lb. is necessarily the sum of the vapor and air pressures, the remaining air pressure would be 14.7 — 11.52 = 3.18 lb. per sq.in. There is a definite relation between the weight of a cubic foot of air, its temperature and its pressure. This is given by the following formula:

$$W = 2.7 \frac{P}{T}$$

where W = density in lb. per cu.ft.; P = absolute pressure, lb. per sq.in.; T = absolute temperature, deg. $F.$ = Fahrenheit temperature + 460.

In the case under consideration P = 3.18 and T = 200 + 460 = 660, so that $W = 2.7 \times \frac{3.18}{660} = 0.013$ lb. per cu.ft.

It is now clear that one cubic foot of this mixture of air and saturated vapor—commonly called saturated air—contains 0.013 lb. of air and 0.0298 lb. of vapor, giving a total weight of 0.013 + 0.0298 = 0.0428 lb. per cu.ft. The weight of moisture per pound of mixture is 0.0298 ÷ 0.0428 = 0.696 lb., and the weight of moisture per pound of dry air is 0.0298 ÷ 0.013 = 2.29 lb.

The case where the total pressure is 14.7 lb. is so common that special tables have been computed in the manner just shown for the pounds of moisture per pound of dry air and per pound of mixture in "saturated air at atmospheric pressure." The quotations are used to call attention to the fact that this expression, while convenient, is not exactly descriptive, as already explained. The last two columns of the accompanying table were figured in this manner. These have many practical applications.

Referring to these columns, it will be noted that the data given for 200 deg. check those just figured. At 212 deg. the mixture is all vapor, since at this temperature the pressure of saturated vapor is atmospheric (14.7 lb. absolute), leaving no margin whatever for the air pressure, if the total pressure is not to exceed 14.7 absolute. The table does not go beyond 212 deg. for the simple reason that it is impossible to have saturated vapor at higher temperatures without raising the pressure above 14.7 lb. absolute. Similar tables could of course be computed for any other total pressure if desired.

Not only does water evaporate in a tank of air as if the air were not present; the same holds for the vapors of two or more liquids, provided the liquids cannot mix (like alcohol and water). The sketch shows a tank containing air, saturated water vapor and saturated gasoline vapor. The quantity of each vapor present is the same as if the air and the other vapor were absent. The total pressure exerted is the sum of the air pressure and the two vapor pressures.

Notes on the Corrosion and Protection of Condenser Tubes*

By G. D. Bengough and R. May

THIS report comprises in 36 small pages a résumé of the present state of knowledge with respect to the causes and remedies for the corrosion of condenser tubes. The original is so condensed that an abstract can be little more than an extended table of contents. Those actively interested in the subject should consult the original. It has been prepared with a strictly practical aim in the hope that it will be of service to manufacturers and operators, and it embodies new and important information. The problem is difficult because condenser plants operate under various conditions, so that some of the recommendations must be in general terms. No remedy applies to all cases.

This report applies chiefly to tubes of 70:30 brass or 70:29:1 (Admiralty) alloy, using sea or estuarine water. Observations have been made on copper and nickel-copper alloys with and without small quantities of arsenic, but it has been found that conditions vary so widely that more experience is necessary before conclusions can be reached.

The subject of tube corrosion is particularly complicated because it is concerned with three types of factors: (a) Involved chemical and electrochemical reactions, (b) physical conditions and (c) metallurgical factors. Not only do these factors vary from tube to tube, but they are far from uniform even in a single tube.

The Mechanism of Corrosion

When brass is immersed in clean sea water, a film of insoluble corrosion products soon forms over the surface and hinders the diffusion of the corroding water to the metal, and the action slows down. This is the metal's natural means of protection against corrosive action and accounts for the different behavior of new and old tubes. Six things may happen to an initially protective film to modify its effect, as follows: (1) The film thickens uniformly, forming the protective scale under which slow action takes place; (2) the film thickens and blisters, and its porosity becomes non-uniform; (3) foreign substances or loose corrosion products settle on the film; (4) the film is eroded away; (5) the film loses its adhesive power through chemical change and falls away from the metal; (6) the film is not formed or is dissolved. This is not discussed in the report, owing to lack of data.

Types of Corrosive Action in Condensers

1. Slow general action under a protective scale. Tube failures appear only after many years unless some other type of action supervenes.

2. Pitting and plug dezincing are characteristic of tubes containing arsenic and free from arsenic, respectively. Both originate from pores in the metal or blisters or fractures in the scale.

3. Deposit attack, due to loose corrosion products and foreign substances, is a comparatively slow action, thinning the tube over considerable areas as distinct from pronounced local action.

4. Impingement attack due to erosion of scale common in condensers using high water speed.

5. Scale kept thin by chemical action, resulting in general corrosion and in isolated pits.

6. Absence of scale owing to acids, etc., resulting in general thinning.

Very slight differences in operating conditions may result in considerable differences in the types of corrosive action observed, so that it is quite common to find more than one type in any one condenser and even in adjacent portions of a single tube.

Causes of Tube Failure

Except in rare cases corrosion takes place on the water side of the tubes, and in practice it usually happens that many of the factors listed below are not under control of the engineers in charge. Frequently, the cause is not a single item but two, three or more, working together.

1. *Causes of Failure Due to Tubes*

a. *Laminations*, etc. (defects in the metal formed during drawing) do not initiate corrosion, but if corrosion starts from other causes, the metal is more likely to be disintegrated in the neighborhood of flaws than elsewhere.

b. Unsuitable *composition*. The discussion covers the effect of tin, lead, iron, manganese, nickel, aluminum and arsenic, some of which are harmful and others helpful under certain conditions.

c. Unsuitable crystalline *structure*. Tubes with a coarse crystal structure have occasionally been found to corrode more violently than those with a fine structure.

d. *Mechanical* failures. Hard tubes often fail by splitting, and soft tubes, by collapsing within the packing.

2. *Causes of Failure Due to External Conditions*

e. Impingement of aërated water streams causes violent corrosion at the inlet ends of tubes. Bubbles of medium size appear to be more harmful than very large or very small ones, and flow conditions influence bubble size. Plant organisms increase the oxidizing conditions in the tubes.

f. *Local changes* in the original scale, and

g. The presence of certain *injurious substances* in the cooling water. It is convenient to take these together. They constitute a vast and complicated subject which has been only very imperfectly explored. Unfortunately, except in a few extreme cases, the water composition is only one of several factors that determine corrosion. Other factors are water speed, the presence of entrained air and of foreign bodies, the temperature of operation, etc. The content of dissolved oxygen or carbon dioxide is likewise very important, and the presence of animal and vegetable products, sewage contamination, etc., have marked influence. Hydrogen sulphide is frequently found dissolved in water. Ammonia-producing bacteria can cause heavy corrosion. In the estuaries of certain tropical rivers the waters occasionally give rise to remarkable corrosion phenomena not paralleled in England. It has been noticed in England that corrosion is much more active during the summer than during the winter. Corrosion is affected by the practice of having condensers standing idle, either empty, partly empty, or full of water.

h. *Mechanical injury* to a protective scale, either through collapse of the tube under the packing or during the process of cleaning. In many condensers a thin protective scale is formed in close contact with the metal, but in some cases, unfortunately, it is covered by a loose, slimy deposit which interferes seriously with heat transfer, and frequent cleaning is necessary. Steel wire brushes are likely to scratch the surface, and pits are often found distributed along these scratches.

i. *High water temperature* increases the danger of dezincification and pitting, but has little effect on the impingement type of attack.

j. Excessive *vibration* may assist corrosion by injuring the protective scale, and the tube wall may be worn away externally.

k. Tube troubles may be caused by *unsuitable packing*, either through chemical action with the packing or through the collapsing of the tube due to the expansion of the packing. Metallic packings appear to be satisfactory, and it is claimed that when they are used, screwed ferrules may be dispensed with, but the authors have no experience with this arrangement. Linen or cotton packing has given excellent results from the corrosion point of view. Cases have been noticed in the laboratory in which a tube insulated electrically from the tube plate has suffered more from impingement attack than a tube in close electrical contact with the tube plate. It is possible when non-metallic packings are used that certain tubes may be insulated from the tube plate.

l. Sometimes *ferrules* give trouble through corrosion, more particularly when made of 60:40 brass. Ferrules may disturb the water entering the tube and thus give rise to impingement attack on the tube, which may be reduced by the use of ferrules of stream-line section.

m. *Stray* currents from electrical machinery may possibly be an occasional cause of corrosion, but the authors have not had experience with any case of corrosion that could be ascribed definitely to this cause.

*Abstract of a bulletin of the Institute of Metals (London, England) prepared by the Corrosion Research Committee. Mr. Bengough was formerly investigator to the committee and Mr. May is the present investigator. The chairman, Prof. H. C. H. Carpenter, has written an introduction to this report, which is published by the Institute at 36 Victoria St., Westminster, S.W.1.; price 2 shillings and sixpence.

n. In a few cases where the steam inlet to the condenser has been severely restricted, *steam erosion* on the outside of the tubes has been noted.

o. *Chance effects.* Two cases are known in which extensive tube failure was due to the mercury from a broken thermometer finding its way into the condenser. Overheating of the condenser upon failure of the cooling-water supply has been observed to start violent dezincification, which continued after normal conditions were re-established.

Possible Methods of Lessening Corrosion

It must be borne in mind that the perforation of a tube is seldom the result of one cause. It is usually the final result of a number of causes operating over a long time. The relative importance of the various factors is unlikely to be the same in any two condensers, and a remedy found useful in one case may be quite useless in another. Difficulty arises from the fact that the methods of protection most obvious from a chemical point of view are frequently impracticable from an engineering standpoint. The following is a statement of the possible methods of lessening the corrosion of 70: 30 or 70: 29: 1 tubes:

1. *Water treatment.* Filtration, while very desirable, is usually impracticable; all that can be done is to screen the water. The entrance of mud may sometimes be reduced by attention to the intake. The removal of entrained air, highly desirable, is probably impracticable, but it is possible to affect the distribution of air by avoiding excessive turbulence or vortex motion, such as might be due to sudden bends at inlets or sudden changes of velocity. Improvement in the stream lining of ferrules seems desirable, but the behavior of the water in the tubes is the result of many interdependent factors, and the readjustment of any one may have little or an unexpected effect. The removal or proper distribution of air is most desirable for condensers using high water speed. The chemical treatment of cooling water such as hardening, softening or neutralizing, is occasionally applicable in fresh-water plants, especially when cooling towers or ponds are used. Slight chlorination of cooling water seems effective in killing or preventing the growth of organisms upon the tube wall, making it unnecessary to employ means of tube cleaning which promote corrosion.

Electrolytic protection is likely to be unsatisfactory, because it is virtually impossible to secure a uniform distribution of current over the tube plates and throughout each tube. Moreover, the electrodes disturb water flow and give rise to unsatisfactory concentration of air bubbles.

2. *Tube treatment.* It has long been known that under certain conditions an insoluble and resistant layer could be formed on the surface of condenser tubes. Various processes for forming such layers are described and discussed. Some seem to yield very promising results.

A coating of tin on the inside of tubes seems to yield divers results, in some cases useful, in others, harmful. Lead coatings gave good results until high water speeds were used, when the coating failed rapidly.

The protection of tubes by a layer of inert substance, such as paint or varnish, interferes with heat transfer. When a drop in vacuum of $\frac{1}{4}$ or $\frac{1}{2}$ inch is not serious, such methods may be useful. Oils and greases have been tried. A coating of boiled linseed oil on tinned tubes gave practically complete protection for twelve months at low water speed. The effect on vacuum is unknown.

Effect of Tube Cleaning

Tube cleaning is usually directed to improving heat transfer, and the effect on corrosion is overlooked. It seems probable that the milder forms of mechanical treatment have little effect on corrosion, save through removing harmful products. The more severe forms may have a positively harmful effect, through injury to the scale and even cutting grooves in the metal, which sets up conditions favorable for the production of pits along the grooves. Improvement of heat transmission may thus be obtained at the cost of tube losses, and commercial considerations must decide the issue. In special cases chemical methods of cleaning have proved satisfactory. The authors have found no record that cold or slightly warm dilute hydrochloric acid has had any bad effect.

When high-speed aërated water streams are used, the low-temperature annealing of finished tubes seems to have no value. Small crystal structure seems not to reduce the likelihood of corrosion. It seems possible that some other factor has operated in favorable experiments, confusing the issue.

Three pages of tables summarize the foregoing discussion of protection processes.

Further Work on Condenser-Tube Corrosion

The general nature of the causes and mechanism of corrosive action are known with some degree of certainty; a number of details, however, remain to be cleared up. Most protective measures appear to have given good results for some particular type of corrosion; against other types the result may be nil, harmful, or still undetermined. To clear up uncertainties, the Corrosion Research Committee is carrying out further work. Among the topics of study are the tube composition, the effect of metallic and non-metallic coatings, the conditions under which scale may be formed or prevented, and the practical conditions under which rapid types of pitting attack the place.

Continuous touch is maintained with a number of power stations and shipping companies which have permitted their condensers to be examined periodically, and in some cases have allowed special experiments.

An appendix discusses briefly the oxygen concentration cell, the metal-ion concentration cell, and the effect of corrosion products on electrode potentials—three elements in the electrolytic theory of corrosion.

Conserving Coal in Great Britain*

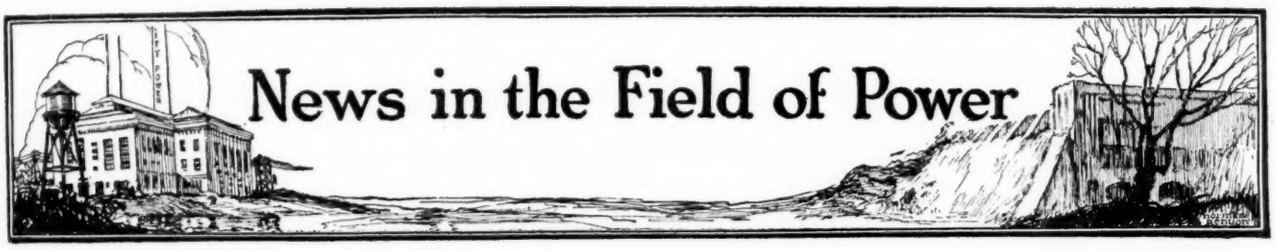
The adoption of pulverized-fuel firing and the competitive methods and improved scientific principles of steam and power generation stimulated by its progress, are going to lead to an enormously reduced consumption of coal in Great Britain. It is estimated that 40 to 50 million tons of coal could be saved each year by improving existing methods.

Out of the 260 million tons of coal mined in Great Britain, about 75 per cent, or approximately 195 million tons, is consumed at home. Of this around 90 million tons is used for stationary boilers, and by increasing the present average working efficiency from 58 to over 70 per cent, about 20 million tons a year could be saved. Lack of superheating, efficient covering of steam-pipes and condensation losses in general represent another 5 million tons. Many of the operations carried out in the iron and steel industries have a thermal efficiency of less than 10 per cent in spite of the fact that producer-gas firing would give 20 to 25 per cent efficiency.

An opportunity for a big saving in fuel lies with the colliery concerns, through research and investigation work on low-temperature carbonization and similar methods for the scientific use of raw coal. The chief British low-temperature carbonization processes in use at the present time are as follows: (1) British Oil & Fuel Conservative Co. ("Freeman" process); (2) "Fusion" Retort process; (3) Low-Temperature Carbonzation, Ltd. ("Coalite"); (4) "Maclaurin" process; (5) Power Gas Corporation Process; (6) "Pure Coal Briquette" process (Sutcliffe Speakman & Co. Ltd.); (7) "Richards-Pringle" process, and (8) the "Tozer" process. A number of these are beginning to attract the notice of the colliery concerns, and six of them now have plants under active construction, either directly for collieries or in such a way as to provide large-scale experience and operating data. The development of pulverized-fuel firing has greatly improved the possibilities, because it means that all low-temperature fuels can now be used at good efficiency for general furnace work and especially steam generation.

In the coal industry there is an opportunity to utilize low-temperature carbonization to the fullest extent for all grades of fuel, and in the first place secure an increase in revenue from gas, paraffinoid liquid products, sulphate of ammonia, and smokeless fuel, which would more than counterbalance the present inefficient state of affairs and the greatly reduced demand that is bound to come. At the same time it should be able to produce practically the entire liquid-fuel demand of the country, and a large part of the fixed nitrogen as well for the cultivation of the soil, this latter subject being even more important than national fuel economy.

*Excerpts from a paper on "Pulverized Fuel" by David Brownlie, read before the Manchester Geological and Mining Society.



New Hydro Plant for North Carolina

According to the press, the Carolina Power Co., of Sanford, N. C., intends to build a hydro-electric plant of about 40,000 hp. Construction will start within the next few months. The company is developing around 125,000 horsepower.

Heavy Export of Anthracite During August

The total exports of anthracite from the United States during August amounted to 476,046 tons, compared with 462,676 tons in the preceding month. The August exports were the heaviest monthly shipments since June, 1921, and the second highest since August, 1920. These larger exports are due mainly to heavier shipments to Canada, 442,906 and 462,525 tons going to that destination in July and August, respectively. Shipments of anthracite to Cuba, which reached a high for the year of 15,347 tons in July, fell to 8,870 in August.—*Commerce Reports.*

A. S. M. E. Annual Meeting Program Plans Maturing

The forty-sixth annual meeting of the A.S.M.E. will be held in New York City from Nov. 30 to Dec. 4. Judging from the list of outstanding speakers and from the advance plans for technical sessions, the meeting will attract an attendance that will exceed the 1924 event, which was the largest the society ever held, with 2,174 registered. The professional divisions have been at work on their programs in co-operation with the committee on meetings and program since April, and efforts are being exerted to complete the program for publication shortly. About forty-five papers will be presented at the meeting.

One feature of the meeting will be the presentation on Tuesday evening, Dec. 1, of honorary membership in the society to the Honorable Herbert Hoover and to Past-President Worcester R. Warner, just preceding the presidential address by William F. Durand. Following the address there will be the usual reception.

An innovation at the coming meeting will be the delivery of the first Henry R. Towne and Robert Henry Thurston lectures. The Towne lecture will be given by the Honorable Herbert Hoover on Tuesday afternoon at 4:30 and will deal with the relation of engineering and economics. The Thurston lecture on "Engineering and Science" will be given by Dr. Zay Jeffries, of the research department, Aluminum Co. of America, on Thursday afternoon at 4:30.

The annual dinner will be held Wednesday evening, the speaker to be one of the leading statesmen of the country. The program will be short and dancing will follow. An informal get-together will be held on Monday evening.

The Business Meeting on Wednesday afternoon will be featured by the usual Council report and by an especially valuable report on the "Study of Mechanical Engineering Education." It will be followed by a general session at which each of the professional divisions will present reports of progress in their particular fields during the last year, which should be of value in establishing the research and standardization programs of the society.

The auditorium of the building will be used for the National Defense Session on Thursday evening, when industrial leaders will report the progress that is being made in perfecting the national program of industrial preparedness.

The renewal of activity in the field of mechanical engineering is demonstrated by the fact that there will be five sessions at the meeting. The topics to be discussed at the machine-shop and machine-design sessions will be, belt transmission, optical measurement, gears, machine-tool design, spring design, lubrication, torsional stress in shafts, vibration in steam-turbine buckets and vibrations in shafts.

The A.S.R.E. is co-operating in one session which will take up centrifugal compressors in two papers, one dealing with the centrifugal compressor as a refrigerating machine and the other discussing the heat balance of the centrifugal compressor.

The Fuel and Power sessions program will be approached from many more angles than usual. Industrial furnaces will be dealt with exhaustively in one session. The oil and gas power session will take up transmission marine auxiliaries and large gas engines. Industrial power will come in for thorough discussion centered about papers on higher steam pressures and industrial power costs. Power-plant materials will furnish the topic for a strong session at which steel castings, bolt materials, boiler-tube corrosion and refractories will be discussed. A general power session will deal with radiant-heat absorption, the effect of steam bleeding and recent developments at the Colfax Station.

The usual progress reports on the steam investigation and a public hearing on the Power Test Codes will also be held.

Androscoggin River Project Contract Let

Announcement has recently been made by the Central Maine Power Co. that it will go ahead with its $4,000,000 power development above Lewiston-Auburn on the Androscoggin River. The project, known as the Gulf Island Development, will be the largest hydro-electric project yet undertaken in Maine, generating 27,000 hp. with a possible ultimate capacity of 36,000 hp. Preliminary plans call for a dam 2,700 ft. long and 50 ft. high, creating an artificial lake 9 miles long and one mile wide. The power house will be equipped with three 9,000-hp. generators, with possible room for a fourth unit of the same capacity.

The Morton C. Tuttle Co. has been awarded the contract for building the dam and power house. Preliminary surveys are to be made at once, and construction work will start within the month it is announced. According to present plans the project is to be completed by Jan. 1, 1927.

Huge Merger of Northeastern Power Rumored

Unconfirmed rumors in the press suggest that there may be a merger of the newly created New England Power Company for the consolidation of the various power interests to form an electrical power combination that will constitute a Northeastern superpower unit of tremendous size.

While nothing was stated officially, it was suggested that the plan is to tie up the consolidation now under way with the properties of the recently formed Mohawk-Hudson Power Corp., in which the Brady utilities at Utica, Cohoes and Albany, certain United Gas Improvement interests, the Adirondack Power & Light Co., and the Power Corp. of New York (F. L. Carlisle & Co.) are among those involved.

The General Electric Co. is understood to be back of Adirondack Power & Light merger operations through some of its directors and bankers, and these interests are also closely identified with the recent consolidation and operation of the Niagara Falls and Buffalo properties recently merged under the name of the Buffalo, Niagara & Eastern Power Company.

Reports from time to time have told of the probability of the interconnection of the Niagara Falls properties with the Adirondack and Northern New York utilities. The prospective merger of these with the New England Co.'s subsidiary properties and those of the International Paper Co. would thus bring together in one large group the power resources of several states.

American Brown, Boveri Buys Condit Electric Co.

Completion of arrangements whereby the New York Shipbuilding Corp. will recapitalize under the name of the American Brown, Boveri Electric Corp. was announced during the past week. Notices of a meeting for Oct. 14 to vote on the plan have been sent to stockholders of the shipbuilding company.

Announcement was also made that the Condit Electrical Manufacturing Co., of Boston, and the Scintilla Magneto Co. of Sidney, N. Y., had been purchased by the new Brown, Boveri Company.

The new enterprise, it is reported, expects to take a leading part in the manufacture and sale of electrical equipment for every branch of industry in this country. Lawrence R. Wilder will be president of the American Brown, Boveri Electric Corporation, J. Elink Shuurman, an executive of Brown, Boveri & Co., Ltd., will be chairman of the board and personally supervise its affairs, making his headquarters in this country. Marvin A. Neeland, now president of the New York Shipbuilding Corp., will be chairman of the executive committee.

North American Company Buys Mississippi River Power

The North American Co. announced through its president, Frank L. Dame, the completion of negotiations for its second large public-utility acquisition in a month. Control of the Mississippi River Power Co., with gross earnings of $3,191,911 in 1924 and assets of over $50,000,000, has been purchased for a subsidiary of the North American, the Union Electric Light & Power Co. of St. Louis. The North American several weeks ago took over a controlling interest in the Western Power Corp., a New York corporation holding utilities in California and the owner of California's largest single source of hydro-electric power.

Control of the Mississippi River Power system will make possible, Mr. Dame said, the free interchange of power over the largest superpower system in the Middle West, connecting the new Cahokia plant of the Union Electric Light & Power Co. of Illinois on the Mississippi, opposite St. Louis, with the huge hydro-electric development across the Mississippi at Keokuk, Iowa. The Union Electric Light & Power system will then extend from Keokuk on the north to the lead belt of Missouri on the south, a distance of about 250 miles, with consequent benefits, it is believed, to St. Louis and surrounding territory.

This combination of steam and hydro-electric generating sources will permit the utilization of the full flow of water in the Mississippi River, a condition which heretofore is said to have been impossible.

The electric output of the North American system is now larger than that of any group of properties under one ownership, and with the addition of the Mississippi company the system will be one of the largest producers of electricity by water power.

No Funds for Colorado River Development Probable

No federal funds are likely to be voted at the coming session of Congress for any project on the Colorado River, Commerce Secretary Hoover predicts. The East, at best, he says, is not anxious to see money poured into Western ventures. If there is disagreement in the West, a valid excuse at once is afforded other sections to defer action or vote down the proposition.

Secretary Hoover obviously was referring to the Swing-Johnson Bill, which provides for the construction of the Boulder Dam and the all-American canal.

Doubt on the Jurisdiction of Conowingo Project

The Philadelphia Rapid Transit Co. concluded its attack on the Conowingo project at Harrisburg, Pa., on Oct. 5, with Ellis Ames Ballard, of P. R. T. counsel, defying members of the three commissions which have reviewed the evidence and counsel for the Philadelphia Electric Co., which is fostering the hydro-electric development on the Susquehanna River in Maryland, to point out one bit of testimony which would tend to show that the rate-paying public will get a penny's worth of benefit out of the scheme.

William Clarke Mason, counsel for the Philadelphia Electric Co., declared in rebuttal that the possibilities of the project lay in the future, and that while the plan might not show a saving in dollars and cents, its value to the consumer would be proved through the stabilizing of a source of electrical energy.

The full personnel of the Pennsylvania Public Service Commission heard the argument. Seated with Chairman W. D. B. Ainey were Commissioners Scattergood, Evans, Martin, Stewart and W. S. Wise, of Meadville, Governor Pinchot's most recent appointee to the commission.

The Public Service Commission of Maryland, comprising Commissioners West, chairman; Whitman and Harper, and O. C. Merrill, of the Federal Power Commission, attended the session at the invitation of the Pennsylvania body.

The decision of the Pennsylvania Commission, Mr. Ainey announced, would not be reached for a considerable time, particularly since members of the three commissions expressed grave doubt at the hearing concerning the proper jurisdiction of the project as outlined.

Both John B. Gest, assistant city solicitor of Philadelphia, representing that city, and Clarence W. Miles, people's counsel of Maryland, filed statements with the commission, asking that the question of jurisdiction and the exercise of authority over future service and rate fixing be determined before approval of the plan was considered.

The P. R. T., which purchases one-fifth of all the current generated by the Philadelphia Electric Co., was represented, in addition to Mr. Ballard, by Coleman J. Joyce, W. K. Myers, a P. R. T. vice-president, and the members of the legal and engineering corps of the company.

Coal Commission Report Ready in November

The first edition, numbering 6,500 copies, of the report of the United States Coal Commission, will be ready for distribution in November, according to the Government Printing Office. The report will appear in five parts, one of which is composed exclusively of charts and tables.

Exports of Oil Engines

That American builders are not in a position to meet European competition in the export of oil engines is a statement often made by more than one economist. No manufacturer should accept such statement without investigation as to the competitive possibilities of his product.

Oil engines are exported from this country in ever-increasing numbers as is indicated by the sales report of the De La Vergne Machine Co. Of the 17,000 hp. of sales listed as having been made in recent months, over half were for export.

Bridge River Surplus Energy for Flour Mills

Plans of the British Electric Railway Co. for an electric development on the Bridge River in the interior of British Columbia will make possible the development of a flour-milling industry in this province, according to John Oliver, provincial premier. After the company has completed its $30,000,000 program, the surplus electric energy will be ample to operate large flour mills along the line of government-owned Pacific Great Eastern Railway. When the railway is built northward into the Peace River country, it will carry large quantities of grain from there southward for milling and export, the premier said.

May Run Engines On Food Dusts

It is now generally recognized that any inflammable material in the form of a fine suspended dust is explosive if the proportions of air and dust lie within certain limits. Disastrous explosions have occurred in grain elevators, starch factories, flour mills, etc. Undoubtedly, many of these disasters would not have occurred if the dangerous capabilities of the material had been fully appreciated. For some time past the Bureau of Chemistry of the United States Department of Agriculture has been carrying on a general investigation of dust explosions, with a view to their elimination through better design and through popular education. W. A. Noel, an engineer of the Bureau, in charge of its dust explosion exhibit at the recent Chemical Show in New York City, said that the department had given some thought to the possibility of producing power in internal-combustion engines from such industrial dusts as occur in flour mills, grain elevators, etc. It is understood, however, that little has been done by the Bureau in the way of actual experimental work along this line, although the problem may be attacked later.

Government Operation If Necessary, Says McKenzie

All members of the President's Muscle Shoals Commission assembled in Washington Oct. 5, with the announced intention of remaining in continuous session until its report to the President has been formulated, which will probably be through October.

Chairman McKenzie gave out a long forceful statement to the effect that he was disappointed that no one had come forward with a plan to help the government solve the problem of Muscle Shoals. He said that he was firmly convinced that neither the welfare of agriculture nor the best interests of national defense would be served by the continued idleness of the nitrate plants while the power from the dam is dissipated and its economic value to agriculture largely lost. He intends to work out a plan of government ownership and operation of the power and nitrate properties which he states was the intention when the construction was authorized. He says also:

OPERATE THREE DAMS TOGETHER

"I am convinced that there is much to be gained by considering Dam No. 3, Dam No. 2 and the Riverton Dam as a single unit in accordance with the suggestion that has been made by Colonel Cooper. These dams belong together and if the government operates the Wilson Dam, then it should build and operate Dam No. 3 and the Riverton Dam as well.

"The government can build dams with 3 per cent money. Why should it not do so rather than permit the power companies to use money that costs 8 or 10 per cent for that purpose? We all know that the interest charge is by far the largest item in the cost of generating hydro-electric power and the government rate of interest is far less than any rate that these private power companies are likely to have to pay for their money.

"If the Alabama Power Co. and the Tennessee Electric Power Co. and others can make money by building dams and distributing power with money raised by them at 7 or 8 per cent interest or more, and if they can pay dividends on watered stock as well as on securities based upon actual capital investment, then I don't see why the federal government cannot make money by developing the water powers of the Tennessee River with 3 per cent money and no stock at all—just 3 per cent government bonds at par, which wouldn't cost the taxpayer a penny, for the power would easily pay the interest on these bonds and the annual cost of a sinking fund to return the government's entire investment.

"Loath as I am to have the government engage in business which private enterprise can carry on effectively, I am unwilling to concede that our great government, rich and powerful as it is, must yield submissively to the wishes of any private concerns who do not wish us to operate these plants and who will not help with a plan for operating them themselves."

Grand Jury Indicts Three for "Mackinac" Disaster

Captain George W. McVay and Chief Engineer John A. Grant of the steamer "Mackinac," on which a boiler explosion in Newport harbor on Aug. 18 took a toll of 55 lives, as described in *Power*, Aug. 25, page 307, and Sept. 1, page 348, were indicted for manslaughter and George J. Kelley, general manager of the Blackstone Valley Transportation Co., operator of the ship, was charged with being an accessory before the fact. This was the outgrowth of a partial report returned by the grand jury for Providence and Bristol Counties in the Superior Court on Oct. 2. Counsel for the defendants said that his clients would appear in court to answer the indictments on Oct. 5 or 6.

Power Show Space Almost All Sold

All of the first two floors of the Grand Central Palace, New York City, and 90 per cent of the space on the third floor has been contracted for by exhibitors at the Fourth National Exposition of Power & Mechanical Engineering, to .be held from Nov. 30 through Dec. 5. This is ample evidence that the coming Power Show will present more than its usual quota of the newest devices and apparatus that obsolete rapidly the power plant of today. One of the features of the Show will be a series of lectures on the important developments in power and mechanical equipment during the preceding year.

Oklahoma To Have Large Hydro Project

A water-power enterprise is contemplated in applications filed in Oklahoma City on Oct. 5, for permits for damming the Grand River in eastern Oklahoma. They were by two concerns, each of which is said to have plans calling for the expenditure of $20,000,000.

They are the Oklahoma Hydraulic Co. and the People's Public Service Corp., each with headquarters in Tulsa. The State Draining, Irrigation and Reclamation Commission, with whom the applications were filed, set a hearing for Tuesday. Plans call for erection of three dams. One below Miami would be 155 ft. high. It is said that 275,000 hp. would be created.

N. Y. State Water Power Commissioners Meet

The New York State Water Power Commission on Oct. 5 authorized a license to the Fulton Light, Heat & Power Co. for the use of the surplus waters of the barge canal at the east end of Dam No. 4, Oswego River, Fulton, N. Y. This license supersedes an existing one. The annual rental under the new license will be about $15,000 a year.

The Commission referred to the Attorney-General the enforcement of its determination of a yearly rental charge of $11,000 covering the licensing of the Massena weir which the Aluminum Co. of America, through its power company subsidiary, the St. Lawrence River Power Co., had failed to accept.

Hearings on the application of the Rochester Gas & Electric Corp. for the use of the surplus waters of the barge canal were adjourned in order to gather additional data.

Middle Fork Site Bought by Byllesby

The extensive holdings of the Feather River Power Co. of the Middle Fork of the Feather River in northern California have been sold to the H. M. Byllesby & Co. It is understood that the company will begin construction of a 90,000-hp. hydro plant on Bean Creek, a tributary of the Middle Fork, in the spring of 1926. This transaction does not in any way affect the $8,000,000 program of the Feather River Power Co. for the construction of a 60,000-hp. plant on Buck's Creek. Construction work is to start on this plant immediately and it is scheduled to go into operation on Oct. 1, 1927.

Personal Mention

Capt. Ralph Earle, formerly with the United States Navy, has been chosen as president of the Worcester Polytechnic Institute.

E. A. Reilly, K.C., minister without portfolio in the New Brunswick government, has been appointed chairman of the New Brunswick Electric Power Commission.

Roderick D. Donaldson, who has been conducting a general consulting-engineering business since February, 1919, at 37 West 39th St., New York City, has joined the J. G. White Management Corporation, 33 Liberty St., New York, as assistant chief engineer.

Edwin Kurtz, assistant professor of electrical engineering at the Iowa State College at Ames, has resigned to accept a position as head of the electrical engineering department at the Oklahoma College of Agriculture & Mechanics Arts, Stillwater, Okla.

Kerr Atkinson, who for the past six years has been associated with Roderick D. Donaldson, of New York, in general consulting work, is joining the staff of Jackson & Moreland, consulting engineers, of Boston. Mr. Atkinson has been engaged on power problems, including the application of pulverized coal in boiler rooms.

G. A. Bole, superintendent of the Ceramic Experiment Station of the Bureau of Mines, Columbus, Ohio, has been designated as supervising ceramist of the bureau and as such will have technical supervision of all ceramic investigations carried on at both the Columbus station and at the other experiment or field stations.

Charles H. Pierce, widely known among New England water-power engineers for his constructive work in establishing and maintaining stream-flow

measurements and for his knowledge of water-power resources in the Northeast, has resigned his post as district engineer of the United States Geological Survey, water resources division, for New England, and on Nov. 1 will join the staff of Charles T. Main, mill architect and engineer, Boston, Mass.

Society Affairs

The Providence (R. I.) Engineering Society has decided to issue a weekly blletin called *Engineerings.*

The Boston Sections of the A.S.M.E and **A.I.E.E.** will make an inspection trip by automobile to Montaup station on Oct. 17.

The A.S.M.E. has a proposed hydraulic division under consideration. The proposal is meeting with great favor it is reported and plans for its formation are being pushed.

The Chicago Section of the A. S. M. E. and about twelve other organizations are to feature Management Week, Oct. 19-24, which will have as its general topic "Waste in Distribution."

The Engineers Club of Philadelphia will hear E. B. Craft, executive secretary of the Bell Telephone Laboratories, speak on "Today's Research—To-morrow's Engineering," at its Oct. 20th dinner meeting. Discussion will follow the speech.

The Plant Engineers' Club of Boston will hear Mr. Idell of the Babcock & Wilcox Co., Boston, give an illustrated talk on "Modern Boiler Practice," at its dinner meeting on Oct. 14 at the Boston City Club.

The Worcester Section of the A.S. M.E. will give a complimentary dinner on Oct. 15, to Capt. Ralph Earle, formerly of the U. S. Navy, who was inaugurated as sixth president of the Worcester Polytechnic Institute on Oct. 6. Captain Earle will speak on "Engineering in the Navy."

The Metropolitan Section of the A.S.M.E. will hold its Nov. 12 meeting at the Engineering Building, 29 West 39th St., New York City. The subject will be "Subterranean Heat as a Source of Energy." The speakers will be Prof. L. P. Breckenridge, George Otis Smith and J. D. Halloway. John W. Lieb will preside.

Business Notes

The Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., announces some changes in its district offices: The El Paso and Phoenix offices have been consolidated under the direction of E. D. Stewart as branch manager of the El Paso office, and W. G. Wilson has been appointed local manager at Phoenix and will report to Mr. Stewart at El Paso; J. H. Knost, formerly branch manager of the Phoenix office, has been appointed industrial and power sales engineer for the entire Los Angeles district and will be located at the Los Angeles office; R. A. Hopkins, who has been manager of the engineering division, Los Angeles district, has been appointed central-station division manager; J. C. Jones has been appointed assistant manager of the central-station division and will be responsible for the sale of supply apparatus throughout the Los Angeles district.

Coming Conventions

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Convention at Engineering Building, New York City, Feb. 8-12, 1926.

American Marine Exposition. Peter A. Sensenrg, 15 Park Row, New York City. Exposition to be held in the 212th Anti-Aircraft Armory, 62nd St. and Columbus Ave., New York City, Nov. 9-14.

American Society of Civil Engineers. George T. Seabury, 29 West 39th St., New York City. Fall meeting at Montreal, Oct. 14-16.

American Society of Mechanical Engineers—Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 30-Dec. 4.

American Society of Refrigerating Engineers, William H. Ross, 154 Nassau St., New York City. Annual meeting at New York City, Nov. 30-Dec. 2.

American Welding Society. M. M. Kelly, 33 W. 29th St., New York City. Fall meeting and Exposition of Welding Equipment and Accessories at the Massachusetts Institute of Technology, Cambridge, Mass., Oct. 21-23.

Association for the Advancement of Science. Burton E. Livingston, Smithsonian Institution, Washington, D. C. Annual meeting at Kansas City, Dec. 28, 1925, to Jan. 2, 1926.

Association of Edison Illuminating Companies. Preston S. Miller, 80th St. and East End Ave., New York City. Annual meeting at New Arlington Hotel, Hot Springs, Ark., Oct. 19-23.

Eastern Ice Manufacturers Association. W. H. Ross, 35 Warren St., New York City. Convention at Atlantic City, Nov. 23-25.

Electric Power Club, S. N. Clarkson, B. F. Keith Bldg., Cleveland, Ohio. Fall meeting at Briarcliff Manor, N. Y., Oct. 19-22.

Midwestern Engineering Exposition, Inc. George E. Pfisterer, 53 West Jackson Boulevard, Chicago, Ill., general manager. Exposition and power show to be held in Chicago, Jan. 26-30, 1926.

National Association of Practical Refrigerating Engineers, Edward H. Fox, 5707 West Lake St., Chicago, Ill. Sixteenth annual convention and educational exhibition at Statler Hotel, Detroit, Mich., Dec. 8-12.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St., New York City. Forty-ninth convention and manufacturers' exhibition, at Atlantic City, Young's Million Dollar Pier, May 17-21.

National Exposition of Power & Mechanical Engineering. Fred W. Payne and C. F. Roth, Managers, Grand Central Palace, New York City. Exposition at Grand Central Palace, Nov. 30-Dec. 5.

Society of Naval Architects and Marine Engineers. Daniel H. Cox, 29 West 39th St., New York City. Convention at the Engineering Building, 29 West 39th St., New York City, Nov. 12-13.

The Diamond Power Specialty Corp. of Detroit announces that the territory of the Lathrop-Trotter Co., 733 Union Trust Bldg., Cincinnati, Ohio, who have been sales representatives for the corporation in the Cincinnati territory for many years, has been extended to take in Indianapolis and the adjacent territory in central and southern Indiana.

Trade Catalogs

Instruments, Temperature — The Brown Instrument Co., 4512 Wayne Ave., Philadelphia, Pa. Catalog No. 87 covers the automatic temperature-control instruments; indicating, recording, signaling and alarm, manufactured by this company. It is well illustrated with pictures of installations and instruments and contains various charts.

Steam-Jet Ash Conveyors — The United Conveyor Corporation, Old Colony Bldg., Chicago, Ill. "Material Design and Construction of the United Steam Jet Conveyor" is the title of a new bulletin recently issued by this company. It is illustrated with dimensioned drawings and contains information concerning the function and operation of these conveyors.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; *mine run* except Pittsburgh gas slack:

Bituminous, Net Tons	Market Quoting	Oct. 5 1925
Pool 1	New York	$2 75@$3.00
Smokeless	Boston	2.10
Clearfield	Boston	1 70@ 2.00
Somerset	Boston	1.85@ 2.15
Kanawha	Columbus	1 55@ 1.85
Hocking	Columbus	1 50@ 1 85
Pittsburgh	Pittsburgh	2.00@ 2.15
Pittsburgh gas slack	Pittsburgh	1.50@ 1 60
Franklin, Ill.	Chicago	2.25@ 2 50
Central, Ill.	Chicago	2.00@ 2 25
Ind. 4th Vein	Chicago	2.25@ 2.50
West Ky.	Louisville	1.25@ 1.50
S. E. Ky.	Louisville	1.50@ 1.75
Big Seam	Birmingham	1.60@ 2.00
Anthracite, Gross Tons		
Buckwheat No. 1.	New York	$2 50@$3.00
Buckwheat No. 1.	Philadelphia	2.60
Birdseye	New York	1.60

FUEL OIL

New York—Oct. 8, light oil, tank-car lots; 28@34 deg. Baumé, 4¾@5c. per gal., 36@40 deg. 5@5¼c. per gal., f.o.b. Bayonne, N. J.

St. Louis — Oct. 1, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.85 per bbl.; 26@28 deg., $1.90 per bl.; 28@30 deg., $1.95 per bbl.; 30@32 deg., $2.00 per bbl.; 32@36 deg., gas oil, 4.91c. per gal.; 38@40 deg., 6c. per gal.

Pittsburgh—Sept. 30, f.o.b. local refinery; 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., fuel oil, 5½c. per gal.

Dallas—Oct. 3, f.o.b. local refinery; 26@30 deg., $1.45 per bbl.

Philadelphia — Oct. 1, 27@30 deg., $2.15@$2.21 per bbl.; 18@22 deg., $1.848@$1.908; 13@19 deg., $1.575@ $1.635 per bbl.

Boston—Oct. 5, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4¼c. per gal.; light oil, 28@32 deg. Baumé, 5¾c. per gal.

Cincinnati — Oct. 6, tank-car lots, f.o.b. local refinery, 24@26 deg., Baumé, 5¼c. per gal.; 26@30 deg., 5¾c. per gal.; 30@32 deg., 5¾c. per gal.

Chicago—Oct. 6, tank-car lots, f.o.b. Oklahoma, freight to Chicago 92c. per bbl.; 24@26 deg., $1.10 per bbl.; 30@32 deg., $1.25.

New Plant Construction

Calif., Long Beach—F. B. Dunn is receiving revised bids for the construction of a 12 story store and hotel building including steam heating system and electric elevators. Estimated cost $1,000,000. Walker & Eisen, 701 Great Republic Life Bldg., Los Angeles, are architects. Former bids rejected.

Calif., Los Angeles—E. L. Doheny, et al, is having preliminary plans prepared for the construction of a 12 story theatre and office building at 11th and Hill Sts. Estimated cost $1,000,000. Morgan, Walls & Clements, 1124 Van Nuys Bldg., are architects.

D. C., Washington—U. S. Engineer Office, 1068 Navy Dept. Bldg., will receive bids until Oct. 27th for furnishing and installing 3 hydraulic turbines for water supply.

Ga., Rome—Atlantic Ice & Fuel Corporation, Washington St. Viaduct, Atlanta, plans the installation of electrical operated machinery in present steam plant here. New equipment will be purchased.

Ga., Rome—The Davis Foundry & Machine Works, 205 West 5th Ave., is in the market for two 150 to 200 hp. boilers.

Ill., Chicago—A. G. Halas, 4732 North Racine Ave., will soon receive bids for the construction of a 12 story hotel at Leland and Racine Aves. Estimated cost $1,100,000. L. G. Hallberg & Co., 116 South Michigan Ave., are architects.

Ill., Chicago—E. M. Levin, 177 North State St., awarded contract for the construction of a 3 story apartment at 2322-2328 Commonwealth Ave. to Calmer Construction Co., 177 North State St. Estimated cost $585,000.

Ill., Chicago—R. Matteson, 565 Diversey Parkway, will receive bids about Nov. 1st for the construction of a 13 story hotel, including 2 passenger and 1 freight elevator at Sedgwick St. and Webster Ave. Estimated cost $2,000,000. Hooper & Janusch, 879 North State St., are architects.

Ill., Chicago—P. F. W. Peck, 80 East Jackson Blvd., awarded general contract for the construction of a 12 story recreation, stores and office building at Wabash Ave. and Congress St. to R. F. Wilson & Co., 53 West Jackson Blvd. Estimated cost $700,000.

Ill., Staunton—City postponed date for taking bids for waterworks improvements, including dam, spillway, 2 m.g.p.d. filter plant, steam heating plant, one 500 g.p.m. 50 ft. head, one 500 g.p.m., 125 ft. head, 1,000 g.p.m., 125 ft. head motor driven pumps, 100,000 gal. tank on tower, etc. W. A. Fuller Co., 1917 Railway Exchange Bldg., St. Louis, Mo., is engineer.

Ia., Cedar Rapids—First Avenue Realty Co., W. K. Wisner, Secy. and Treas., 2 Waterhouse Blk., is having plans prepared for the construction of an 8 story hotel at 1st Ave. and 2nd St. E. Estimated cost $800,000. J. W. Fitzpatrick is architect and N. H. Hatton is associate architect.

Ia., Des Moines—Westbury Arms Co., c/o F. C. Waterbury, 136 East Locust St., plans the construction of an 8 story apartment at 19th and Ingersoll Aves. Estimated cost $600,000. W. D. Holtzman, Jr., 502 Commonwealth Bldg., is architect. H. W. Hartupee, 204 Masonic Temple, is engineeer.

Kan., Wathena—City will soon award contract for the construction of waterworks and distribution systems including pumping equipment, mains, etc. Estimated cost $40,000. E. T. Archer & Co., New England Bldg., Kansas City, Mo., are engineers.

Ky., Ashland—L. Taschell & T. Gresham, 2330 Monument Ave., plans the construction of an 11 story hotel on 13th St. Estimated cost $500,000. Wysong & Bengston, Prof. Bldg., Charleston, W. Va., are architects.

La., Hammond—City, H. A. Mentz, Consulting Engr., will receive bids until Oct. 26th for the construction of a waterworks system including 2 complete units of oil engine pumping equipment, pumping station, filtration plant, etc.

La., Shreveport—The Republic Power & Service Co., Little Rock, Ark., plans the construction of a 50 ton Howe fresh water ice plant on Cotton Belt R.R. tracks here. Estimated cost $200,000. Work will be done with own forces.

Me., Lewiston—Central Maine Power Co., W. S. Wyman, Mgr., Augusta, awarded contract for the construction of a 27,000 hp. power house and 50 ft. dam across the Androscoggin River, at Gulf Island, near here, to Morton C. Tuttle Co., Park Square Trust Bldg., Boston, Mass.

Md., Baltimore—Consolidated Gas Electric Light & Power Co., H. A. Wagner, Pres., Lexington Bldg., will build the first unit to power plant at McComas and Gould Sts. Estimated cost $175,000; total cost $4,000,000. Company engineers in charge.

Md., Baltimore—Parker, Thomas & Rice, Union Trust Bldg., Archts., will receive bids until Oct. 19th for the construction of a 6 story office building at Charles and Chase Sts. for Mutual Life Insurance Co., 15 South St. Estimated cost $500,000.

Md., Havre de Grace—Abbott Bros. plans the construction of addition to ice plant. Estimated cost $30,000. J. L. Barr, 2700 North Charles St., Baltimore, is engineer. Owner is in the market for an oil engine, water pump, belting, etc., for plant.

Mass., Boston—The Madison Inc., c/o W. W. Hoblitsell, Jr., 31 Milk St., awarded contract for the construction of a 10 story apartment at 172-174 Beacon St., to M. W. Ryan, 763 Massachusetts Ave., Cambridge.

Mass., Milford—Milford Electric Light & Power Co., 241 Main St., is having plans prepared for the construction of addition to plant. Estimated cost $40,000. E. L. Rawson, 6 Beacon St., is architect.

Mass., Quincy (Boston P. O.)—Mayor and City Council plans the construction of a new pumping station and sewage system in Squantum and Adams Shore districts. Estimated cost $175,000. Engineer not selected.

Mass., Somerville (Boston P. O.)—Ford Motor Co., Highland Park, Mich., awarded contract for the construction of an assembling plant including power house on Middlesex Ave. here to Blair Construction Co., Rand Bldg., Memphis, Tenn. Estimated cost $4,000,000.

Mich., Detroit—L. Kamper & R. L. Spitzley, c/o L. Kamper, Kamper Bldg., Cass Ave., Archt, has had plans prepared for the construction of a 15 story hotel including steam heating system at Woodward and Adelaide Sts. Estimated cost $2,500,000.

Minn., Minneapolis—Hennepin County has authorized draining in Richfield Township into Lake Nokomis, installation of two electric and one gasoline motor driven pumps, 10,000 g.p.m. combined capacity. Estimated cost $60,000.

Minn., Winona—City will receive bids until Oct. 19th for an electric generator engine unit with auxiliary equipment, three 750 gal. capacity vertical single stage centrifugal sewage pumps with 15 hp. motors. Estimated cost $4,100 and $4,500 respectively. E. E. Chadwick, is city engineer.

Mo., Piedmont—City will receive bids until Oct. 27th for one 150 g.p.m. motor driven and one 150 g.p.m. gasoline engine driven pumps, pump house, etc. Estimated cost $50,000. W. A. Fuller Co., 1917 Railway Exchange Bldg., St. Louis, is engineer.

Mo., St. Louis—Water Dept., E. E. Wall, Dir., is having preliminary plans prepared for the installation of two 30,000,000 g.p.d., two 40,000,000 g.p.d. and one 60,000,000 g.p.d. pumps; water tube drum-type boilers, etc. Estimated cost $412,500, $237,500 and $525,000 respectively.

Neb., Bloomfield—City awarded contract for the construction of a power plant and cooling tower to Beckenhauer Bros., Norfolk, for 75 to 90 hp. oil engine generating unit, 150 to 180 hp. generating unit and auxillary equipment, switchboard, etc., to Fairbanks, Morse & Co., 9th and Harney Sts., Omaha. Estimated cost $8,990 and $27,412 respectively. H. L. Cory & Co., Aberdeen, S. D.

N. J., Glen Gardner—State Institutions and Agencies, B. G. Lewis, Comr., will receive bids until Oct. 26th for new pumps, 200,000 gal. tank on tower, etc., for water supply at state sanatorium. Estimated cost $47,000. A. B. Mills, State Office Bldg., Trenton, is engineer.

N. Y., New York—Authors League of America Inc., 2 East 23rd St., is having plans prepared for the construction of a 20 story apartment and studio building at 122 East 34th St. Private plans.

N. Y., New York—Eight Hundred Twenty Park Ave. Corp., c/o H. A. Jacobs, 64 East 55th St., Archt., is having plans prepared for the construction of a 15 story apartment at Park Ave. and 75th St.

N. Y., New York—Milnat Realty Corporation, c/o H. J. Feldman, 516 5th Ave., Archt., will build a 15 story apartment at 119 West 72nd St. by day labor. Estimated cost $1,500,000.

N. Y., New York—Nineteen John Street Corporation, C. W. Hansen, Pres., 46 Cedar St., awarded contract for the construction of a 15 story office building at 17 John St. to Starrett Bros., Inc., 292 Madison Ave.

N. Y., New York—Schuyler Square Realty Co., c/o J. E. R. Carpenter, 598 Madison Ave., Archt., is having plans prepared for the construction of a hotel at 112 West 59th St. Estimated cost $900,000.

N. Y., New York—Syndicate, c/o M. Heckscher, 50 East 42nd St., plans the construction of a 56 story hotel at 5th Ave. between 57th and 58th Sts. Estimated cost $25,000,000.

N. Y., New York—Twenty-Three West Seventy Third Street Corporation, c/o G. F. Pelham, 200 West 72nd St., Archt., is having plans prepared for the construction of a 15 story hotel. Estimated cost $2,500,000.

O., Canton—Bd. of County Comrs. of Stark County, plans an election Nov. 3 to vote $735,000 bonds for the construction of a tuberculosis sanitorium including boiler room, laundry, etc. Architect not announced.

O., Cleveland—The Cleveland Electric Illuminating Co., E. J. Cook, engineer of construction, Illuminating Bldg., awarded contract for addition to switch house at East 72nd St. to John Gill & Sons, Bulkley Bldg. Estimated cost $175,000.

Okla., Bethany—City plans an election Oct. 20th to vote $45,000 bonds for the construction of a new waterworks and distribution system including well, tank, pump, motor, etc. H. E. Musson, Grain Exchange Bldg., Oklahoma City, is engineer.

Pa., Philadelphia—Philadelphia Shelton Corporation, c/o N. J. Taube, Inc., Central Medical Bldg., awarded contract for the construction of a 20 story hotel at 1709-1715 Locust St. and 1708-1714 Chancellor St., to Barras Construction Co., 366 Madison Ave., New York, N. Y. Estimated cost $2,500,000.

Tenn., Chattanooga—J. Perry, c/o W. H. Sears, James Bldg., Archt., awarded contract for the construction of Fleetwood Hotel on Lookout Mountain, to M. K. Wilson, c/o architect. Estimated cost $1,200,000.

Tenn., Nashville—Bd. of Public Works, is having plans prepared for improvements to waterworks, including filtration plant, mains, pumping plant, etc. Estimated cost $3,000,000. The J. N. Chester Engrs., Union Bank Bldg., Pittsburgh, Pa., is engineer.

Tex., Dallas—American Ice Co., c/o C. E. Kennemer, Pres. and Mgr., 4901 Cole Ave., will build a 100 ton ice plant at 3305 Lemmon Ave. by day labor. Estimated cost $45,000. Private plans.

Tex., North Pleasanton—Pleasanton Electric & Ice Co., awarded contract for the construction of a 10 ton ice plant to Sumner-Sollitt Co., National Bank Commercial Bldg., San Antonio. $17,515.

Tex., Luling—Texas Power & Light Co., plans to electrify its ice plant. Estimated cost $25,000. Private plans.

Tex., Tahoka—City plans an election October 17th to vote $40,000 bonds for improvements to waterworks including pumping equipment, mains, etc.

Wash., Seattle—Fifth Avenue Building Co., Henry Bldg., will soon receive bids for the construction of an 8 story theatre, office and studio building at 5th and Union Sts. Estimated cost $1,500,000. R. C. Reamer, Henry Bldg., is architect.

B. C., Vancouver—British Columbia Electric Railway Co., G. Kidd, Pres., 425 Carrall St., plans the construction of a hydro-electric plant to develop 215,000 hp. on the Bridge River 135 miles north of here. The first units, 60,000 hp., will be completed within five years, cost $13,000,000. The balance over the next 10 years. Total cost $30,000,000. E. E. Carpenter c/o owner is engineer.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

About the only basic material to show a definite price decline during the month was linseed oil. The raw product is down about 3¾c. per gal. in New York, compared with the Sept. 8 level. With rubber prices close to the July, 1925 peak, a decided rise is noted in quotations on rubber hose. Armored cable, flexible cord and rubber tape are also higher.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, sing'e jacket		71c. per ft.
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	45%

Air—Best grade

¾-in., per ft.	3-ply....$0 37½	4 ply....$0.46

Steam—Discounts from List

First grade.....30–10%	Second grade.....40%	Third grade..40–10%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50%	Second grade	50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40%
Heavy	30–10%

RAWHIDE LACING
For cut, best grade, 50%, 2nd grade, 60%.
For laces in sides, best, 41c. per sq.ft.; 2nd, 37c.
Semi-tanned: cut, 50%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$0.90
Asbestos for high-pressure steam, ⅛ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.59
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@$2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	15.00@22.00	19.00	20.00
Colored	10.00@15.50	18.00	17.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed, white wipers, as follows:

Chicago	$0.15½
New York	.17
Cleveland (per thousand)	36.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.04½	$1.15	$1.03

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	$15.75	$14.75	$17.25	$16.25
White	15.75	14.75	15.75	14.75

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Rivets, ⅜x1-in. and longer, 19c. per lb., less 50% at New York warehouses. Same discount for tinned. EXTRA per 100 lb. for 1½ to 2-in. long, all diameters, 25c.; ⅝-in. dia., 35c.; ½-in., dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb., 50c.; countersunk heads, 45c.

Structural rivets, ¾, ⅞, 1 in. diameter by 2½ in. to 4½ in. sell as follows per 100 lb.:

New York	$5.00*	Chicago	$3.50	Pittsburgh	$2.40@2.50

Boiler rivets, same sizes:

New York	$5.20*	Chicago	$3.70	Pittsburgh	$2.70@2.90

* For immediate delivery from warehouse.

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$48@53
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	23@28
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	27@32
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@47
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@45
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	33@40
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	40@43
Chrome ore crude, 40@50%	net ton	19.00@20.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	68.75	58.00@63.00
(35% tin)	28.00	22.50	30.00@35.00

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.15	$3.80	$3.60
Flats, squares and hexagons, per 100 lb. base	4.65	4.30	4.10

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Galv.	Inches	Iron Black	Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17 07
1¼	.....	.....	19 20
1½	.....	$38 00	17 92
1¾	.....	28 50	20 48
2	$17 33	25 00	20 24
2¼	19 84	28 25	23 00
2½	21 60	34 00	26 03
3	25 50	42 50	27 04
3¼	.....	49 50	30 67
3½	31 50	52 75	33 33
4	38 03	67 00	40.11

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.
These prices are net per 100 ft. based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.
In addition to the above, standard cutting charges are as follows:
2 in. and smaller, 5c. per cut. 3 in., 9c. per cut
2¼ and 2½ in., 6c. per cut. 3¼ to 4 in., 10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$36.00 (net)	$ 56.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:	Lead Covered
Less than coil lots	20%
Coils to 1,000 ft.	25%
1,000 to 5,000 ft.	30%
5,000 ft. and over	35%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56 50	$61.34	$7.76	$8.83	$4.52	$4.92
⅜	72.07	78.63	10.21	11.63	6.46	7.03
½	103.31	113.00	15 10	17.21	8.39	9.13
¾	139.77	152.88	20 51	23.07	11.78	12.75
1	167.12	182.79	27.34	30.76	14.56	15.75
1¼	224 85	245 94	50 13	56.40	19.41	21.01
1½	355 50	388 85	82 03	92 28	27.73	30.01
2	464.88	508 50	218 74	246 10	41.59	45.01
2½	585.30	637 74	483 04	543.46	55.46	60.02
3	714 17	776.30	558.23	628.06	69.32	75.02

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG, SOLID NEUTRAL OR 2 FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID NEUTRAL OR 2 FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$23.00
No. 16 cotton reinforced heavy	26.50
No. 18 cotton reinforced light	18.10
No. 16 cotton reinforced light	22.00
No. 18 cotton Canvasite cord	16 75
No. 16 cotton Canvasite cord	19.10
No. 16 super service cord or similar (2 wire)	101.20
No. 14 super service cord or similar (2 wire)	146 40

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	30	35-amp. to 60-amp.	100	.60
61-amp. to 100-amp.	50	90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 65%; standard package, 70%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP OR CLEARSITT—

0-30 ampere, standard package (500)	$2.85
0-30 ampere, less than standard package	3.15

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.27	$0.32	120	50	$0.40	$0.45	60
15	.27	.32	120	75	.45	.55	60
25	.27	.32	120	100	.50	.55	24
40	.27	.32	120	150	.65	.70	24
50	.27	.32	120	200	.80	.85	24
60	.32	.37	120	300	1.25	1.35	24
				500	2.00	2.15	12
				750	3.50	3.70	8
				1,000	3.75	3.95	8

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	08½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$7.20	$9.45	$11.10	$17.60
12	9.45	12.18	14.97	22.90
10	12.90	16.15	17.90	29.45
8	18.00	21.40	23.40	40.45
6	.....	.....	33.70	.....
4	.....	.....	45.87	.....
2	.....	.....	65.63	.....
1	.....	.....	88.43	.....
0	.....	.....	112.25	.....
00	.....	.....	134.00	.....
000	.....	.....	157.50	.....
0000	.....	.....	188.00	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.36	$0.33	$0.50*	$0.42	$0.39	$0.56*

Less 1-5th standard package	30%
1-5th to standard package	40%
Standard package	45%

* Net.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 35c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 37c. lb., 100 lb. lots	35c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%